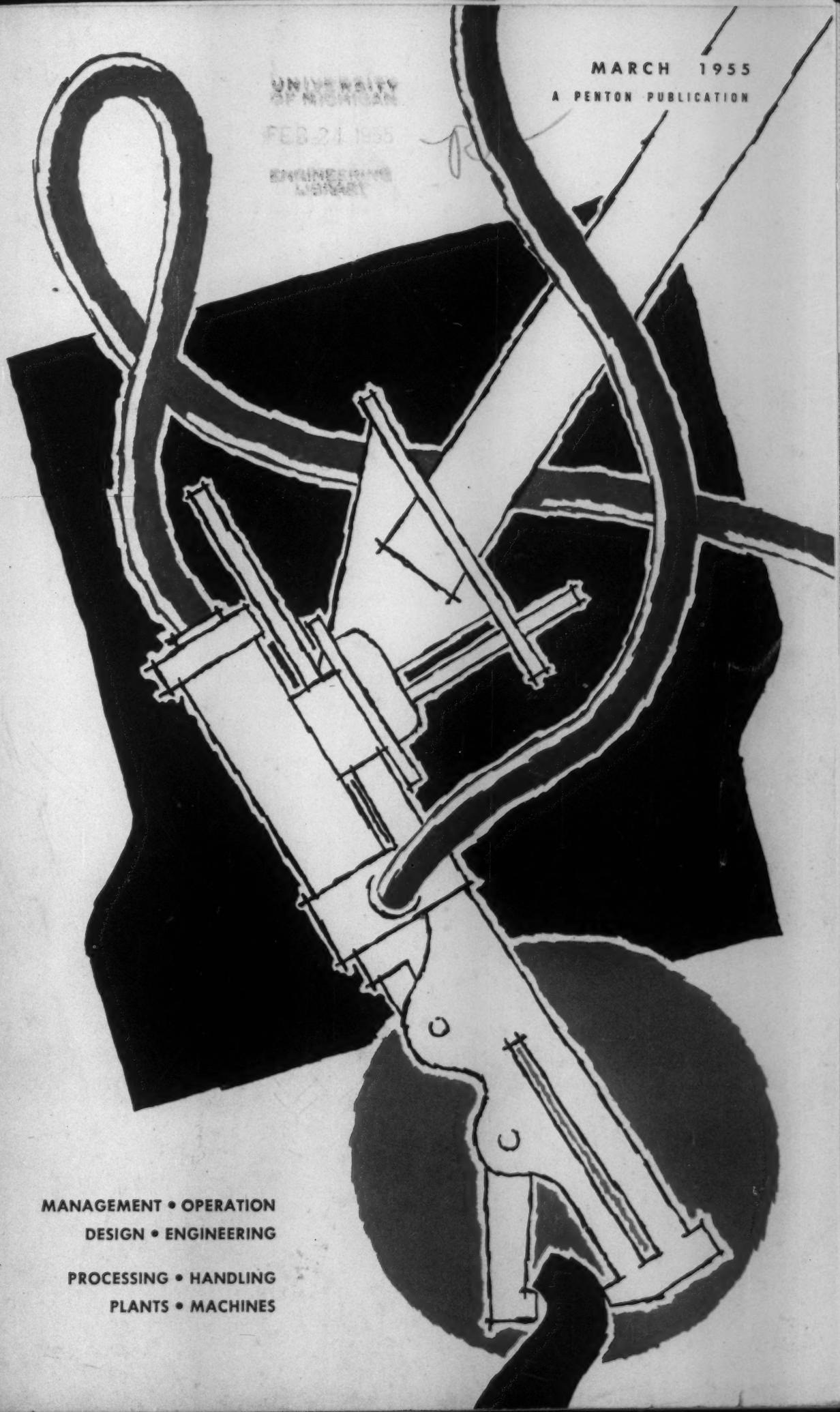
AUTOMATION

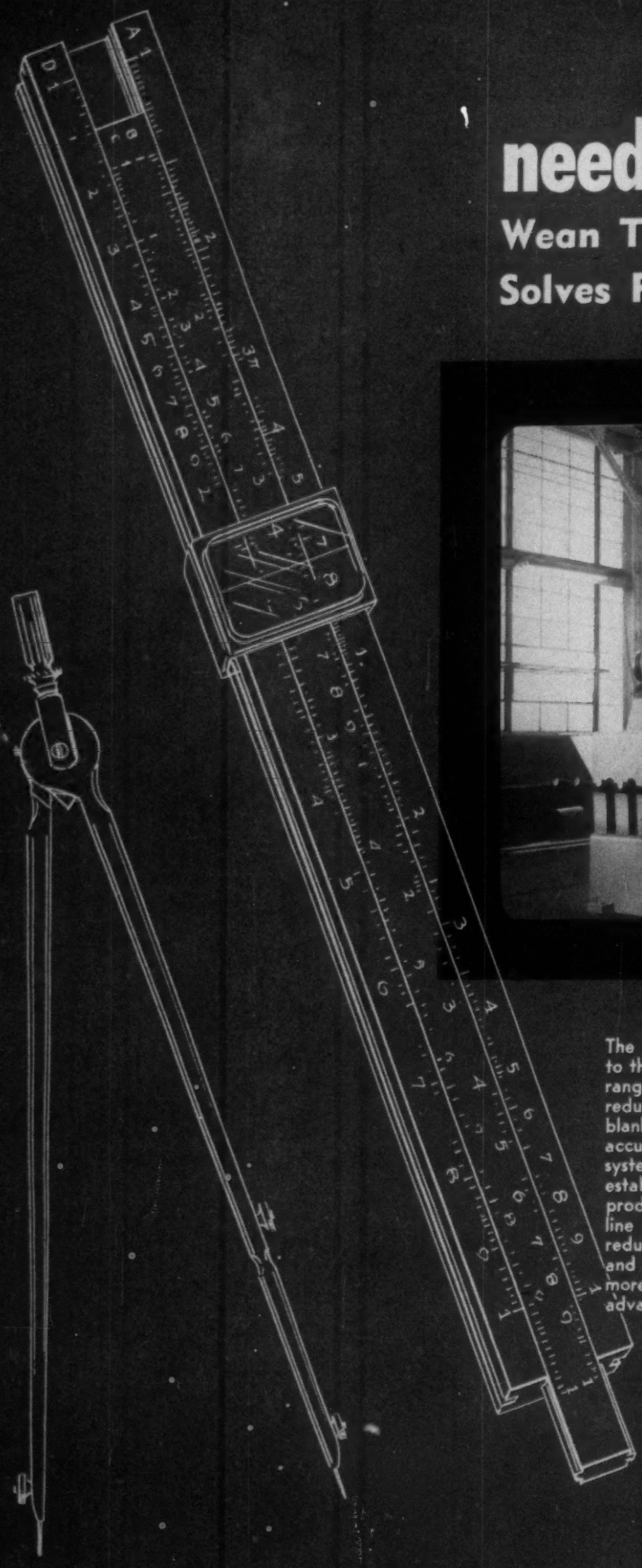
MARCH 1955
A PENTON PUBLICATION

UNIVERSITY OF MICHIGAN
FEB 24 1955
ENGINEERING LIBRARY



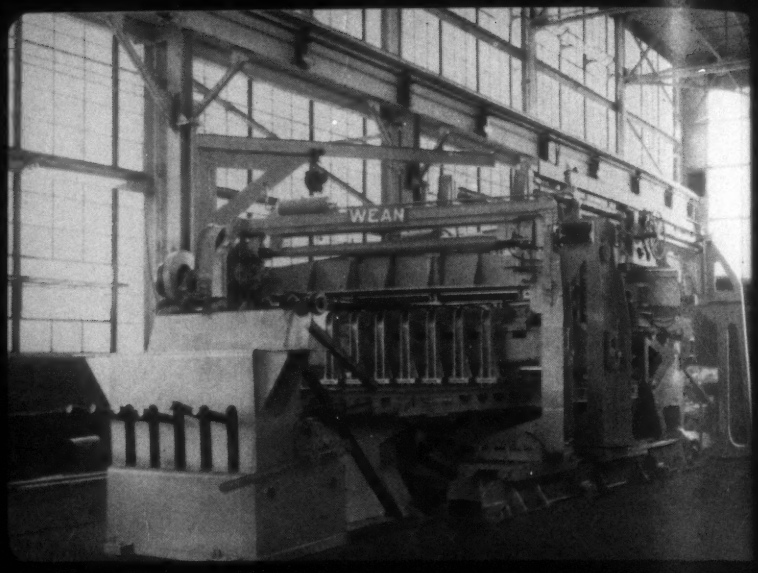
MANAGEMENT • OPERATION
DESIGN • ENGINEERING

PROCESSING • HANDLING
PLANTS • MACHINES



need an idea?

Wean Trapezoidal Shear Line Solves Problem for Auto Maker



The Wean Trapezoidal Shear Line was developed as an answer to the high speed blanking of irregularly shaped pieces in the broad range that can be described as trapezoids or parallelograms. This reduces tremendously the cost of expensive die setup in major blanking presses. Two pieces are made at each index with the accuracy that can only be achieved by a measured length indexing system. The cut can range from 45° to 90° angles. The latter setti establishes the line as a straight cut-up unit with twice the normal production of conventional shear lines. At Wean, we consider th line as another important step forward in our policy of cost reduction through progressive engineering. People in the automotive and metal fabricating fields have come to look more and more toward Wean Equipment for spectacular advances in machinery for metal processing.

Wean

EQUIPMENT CORPORATION
CLEVELAND, OHIO

Offices:
CLEVELAND • DETROIT • CHICAGO • NEWARK, N.J.
Cable: WEANCOR

MARCH, 1955
Vol. 2—No. 3

AUTOMATION

THE MAGAZINE OF AUTOMATIC OPERATIONS

ROGER W. BOLZ, Editor

EDITORIAL STAFF

JAMES C. KEEBLER, Associate Editor
WILBUR R. ELLIS, Associate Editor
JOHN H. McRAINEY, Assistant Editor
FLEUR E. WOODS, Assistant Editor
HELEN M. VERESPY, Editorial Assistant

FLOYD G. LAWRENCE, Detroit Editor

EDWARD D. KARL, Art Editor

Editorial Representative

NORMAN LYNN
Los Angeles, Webster 5-3040

REGULAR DEPARTMENTS

Automation Outlook, 4

Automation News, 14

Detroit Dateline, 23

New Equipment, 77

New Components, 84

New Literature, 94

Abstracts, 98

Patents, 106

Editorial Index, 108

New Books, 110

Answer for Tomorrow, 25
EDITORIAL—predicted demands for increased productivity can be supplied by techniques of automation.

Continuous Heat Treating, 26
W. J. BEHRENS—incorporating furnaces as part of the automatic line yields manufacturing advantages.

Transfer Machining, 33
AUTOMATION TODAY—fifteen in-line stations machine two different automotive parts simultaneously.

Automatic Control Terminology, 37
BLOCK DIAGRAMS—SYMBOLS—CONTROL COMBINATIONS—standard process control terms defined and illustrated.

Inspecting Welded Tubing, 40
INDUCTION INSTRUMENT—nondestructive testing by electrical system which signals presence of flaws.

More Automatic Operation, 41
ROGER W. BOLZ—industry-wide survey reveals plans for extensive application of the principles of automation.

Management of Systems Engineering, 49
E. D. GITTENS—part two—comparison of vertical and committee types of project team organization.

Spray Pickling and Washing Process, 56
CONVEYORIZED EQUIPMENT—moves parts through compartments for continuous metal surface preparation.

Press Forging of Crankshafts, 58
HANDLING MECHANISMS—conveyors, hydraulic and pneumatic positioners integrated with production equipment.

Electronic Tape Control System, 62
A. G. THOMAS—step motor drive performs combined indexing and power functions for machines.

Co-ordinated Pallet Handling, 64
PAYS FOR ITSELF—loading and unloading of noninterlocking cases accomplished by automatic machine.

Hydraulic and Pneumatic Servos, 65
R. HADEKEL—part six—special design considerations encountered in complex servomechanisms.

AUTOMATION OUTLOOK

INTO THE LINE

". . . modern continuous heat treat furnaces, due to design adaptability to accommodate all types of parts of different shapes and sizes, and all methods of material movement, have literally moved from the conventional heat treat department right into the production line. Here they function in essence as machines in the line . . ."—*W. J. Behrens, Marion Mfg. Co.* *See Page 26.*

NOT WANTED AT ANY PRICE

". . . —the machine tool industry looks to the future with optimism because of the dynamic quality of its own technology. This can probably be summed up in one word—automation . . . The American people want automation, because in it they see the evolution of man's age-old desire to eliminate human drudgery. Automation is here to take up the body breaking, unpleasant and unsafe jobs human labor no longer wants at any price. The machine tool industry is in the thick of the automation movement, and it looks forward to leading the way for many years. . ."—*Ralph E. Cross, executive vice president, Cross Co.*

OPERATION WAREHOUSE

". . . major considerations in planning the new Heinz Pittsburgh warehouse were the advantages offered by the latest developments in automatic mechanization of handling. Operation of the handling system in some respects resembles switch tower control of railroad trains entering large passenger stations. It involves making up "trains" of predetermined and widely variable numbers of filled cases and routing and controlling their movements on 13 accumulator conveyors and five trunk conveyors through four pallet loading machines and over subsequent conveyors and vertical lifts to one of the three floors. There are approximately 1½ miles of conveyors, including feeders, accumulators, and trunk lines to the pallet loaders. Other automatic conveyors deliver palletized products from pallet loaders to the floor on which they are to be stored or shipped. . ."—*R. A. Peterson, manager Transportation and Warehousing Div., H. J. Heinz Co.*

NEED FOR PROGRAMMING

". . . it is necessary in any automation process to consistently consider the programming technique to be employed. Programming is meant to imply the storing of information for the actual operating machines, and the sequential or parallel transmission of that information to the machines. In other words, if a single machine were designed to insert components and a separate machine designed to solder those components, sequential signals would have to be transmitted to the machines in automatic fashion to produce a completely automatic operation. It is evident therefore that the machine design and programming technique are closely allied in automation. . ."—*A. Arnold Lawson, Melpar, Inc.*

NO FEEDBACK USED

". . . three identical electronic units in the control cabinet and three step motors cause table travel . . . this system is unique in that there is no hunting, nor is feedback used. Information on the tape determines final shape of the workpiece regardless of change of tape speed, changes in components, change of temperature, or other factors . . ."—*A. G. Thomas, Industrial Controls Corp.* *See Page 62.*

AUTOMATION FOR COMPONENTS

". . . let's remember that the problem of automation extends into the components industry as much as or more than into the equipment industry. Now it is very nice for us as engineers to know how to take a piece of board with wiring on it, dunk it in solder, and get a product. But we are working on a 10 to 20 per cent labor section of which the soldering content of that labor might very well be down in the few per cent range. From the point of view of saving money, components (60 to 80 per cent materials section) is the really fertile field. . ."—*Dorman D. Israel, Emerson Radio & Phonograph Corp.*

AUTOMATION

Penton Building, Cleveland 13, Ohio
Main 1-8260

EDWARD S. LAWSON
Business Manager

BUSINESS STAFF

Elizabeth Root, *Advertising Service Manager*

J. M. Castiglione, *Production Manager*

George J. Auner, *Statistician*

Advertising Representatives

New York 17 .....60 East 42nd St.
Robert G. Macbeth
Fred A. Stanley
Murray Hill 2-2581

Cleveland 13 .....Penton Building
Larry D. Brennan
Gordon W. Rosencrans, Jr.
Main 1-8260

Chicago 11 .....520 North Michigan Ave.
Richard K. Lotz
Richard W. Jones
Whitehall 4-1234

Los Angeles 57 .....2330 West Third St.
The Robert W. Walker Co.
Dunkirk 7-4388

San Francisco 4 .....57 Post St.
The Robert W. Walker Co.
Sutter 1-5568

Griffin, Ga. .....331 South Twelfth St.
Fred J. Allen
Griffin 7854

Circulation

Jack C. Gernhard, *Manager*

Amy Lombardo, *Directory & List Dept.*

Published by

THE PENTON PUBLISHING COMPANY

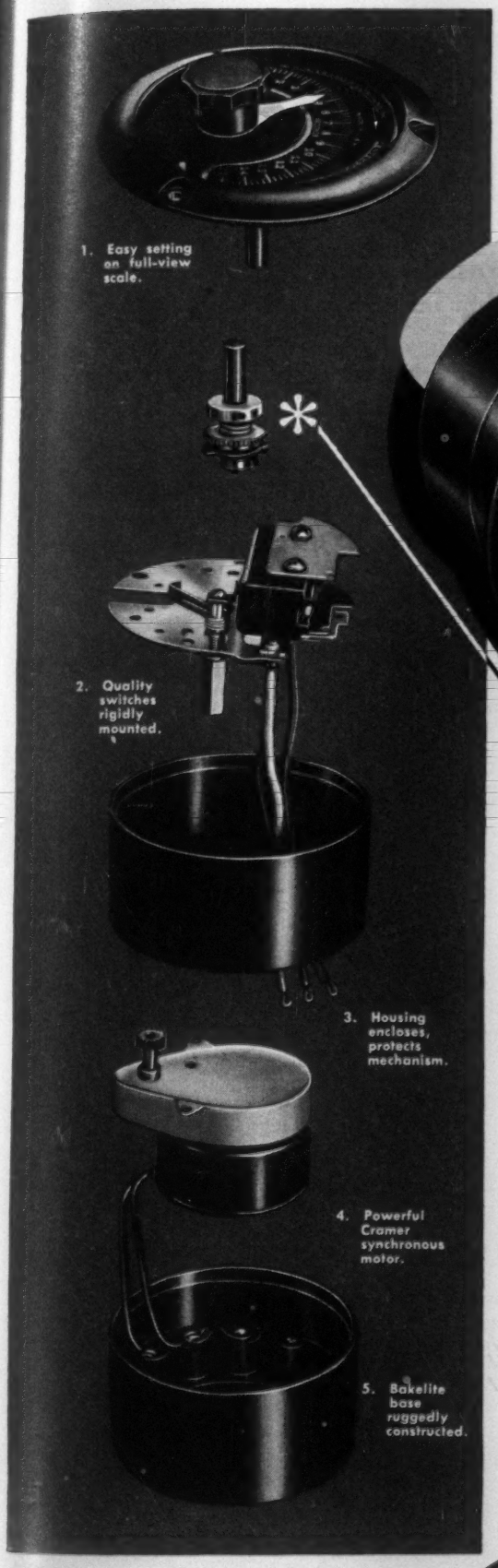
G. O. HAYS .....*President and Treasurer*
R. C. JAENKE .....*Executive Vice President*
F. G. STEINEBACH .....*Vice Pres. and Secretary*
F. O. RICE .....*Vice President*
J. P. LIPKA .....*Asst. Secy. and Asst. Treas.*

Also Publisher of
STEEL • FOUNDRY • MACHINE DESIGN
NEW EQUIPMENT DIGEST

Published monthly. Subscription in the United States, possessions, and Canada: One year $10. Single copies, $1.00. Other countries one year, $20.

Copyright 1955 by The Penton Publishing Company.
Accepted as Controlled Circulation Publication at Cleveland, Ohio.

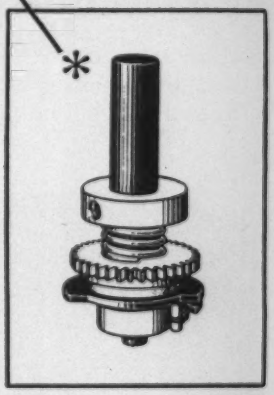
Design Simplicity — Key to Trouble-Free Operation


1. Easy setting on full-view scale.
2. Quality switches rigidly mounted.
3. Housing encloses, protects mechanism.
4. Powerful Cramer synchronous motor.
5. Bakelite base ruggedly constructed.

CRAMER

type 230 INTERVAL TIMER

. . . manually set to control the opening of one circuit and closing of another for a selected time interval.



A "look inside" the Type 230 Interval Timer illustrates how design simplicity and precision workmanship contribute to trouble-free performance.

For example, the friction clutch assembly shown at left has few operating parts, yet is highly efficient. All friction forces are held internally within the clutch. No force is exerted either up or down to cause unnecessary load on the motor. The clutch essentially "floats" in the timer, thus minimizing wear, increasing reliability, and contributing to long motor and timer life.

Every component of every Cramer timer has been designed for simplicity, accuracy and operating dependability. For the complete story on interval timers, write for Bulletin PB-210.

Cramer TIMING DEVICES

SPECIALISTS IN TIME CONTROL

The R. W. CRAMER CO., Inc.

BOX 35, CENTERBROOK, CONNECTICUT

7CR55

AUTOMATION NEWS

Today's events and developments of importance in the field of modern automation

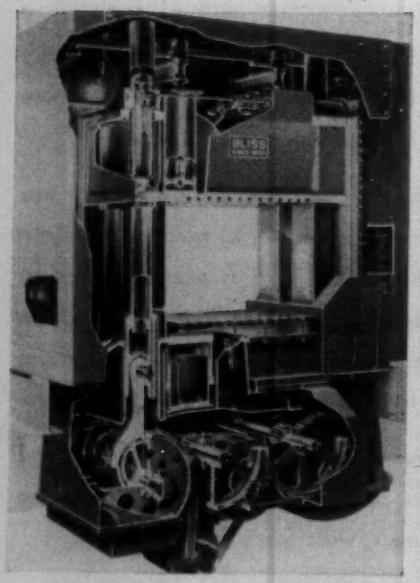
Materials Handling Influences Press Design

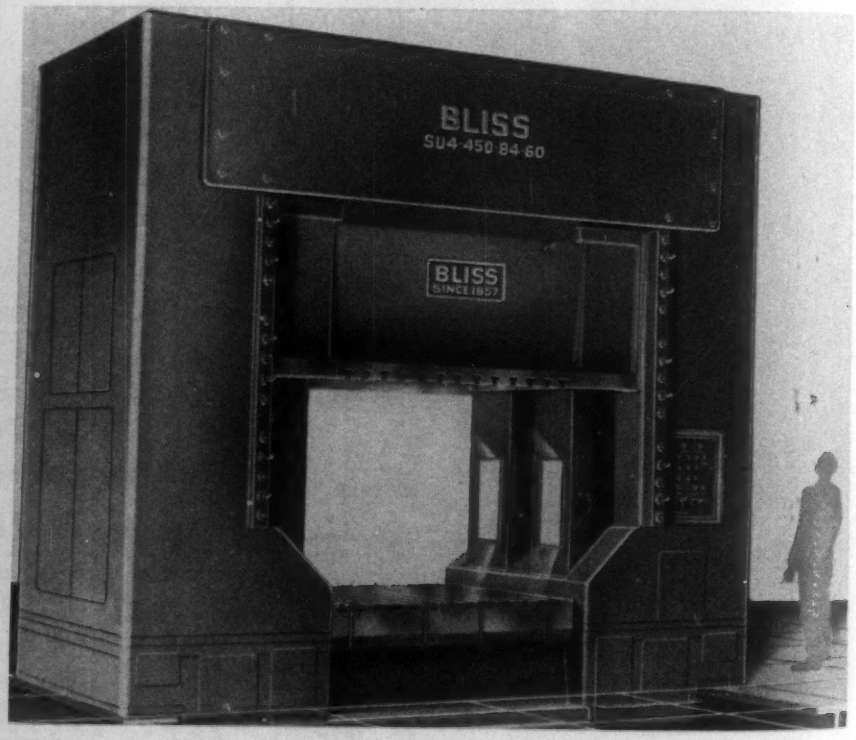
AUTOMOTIVE AND APPLIANCE industries co-operated with E. W. Bliss Co. in the latter's major design program of new presses for forming and drawing large stampings. A major result of this co-operation was the consideration given to arrangements for user supplied automatic materials handling machinery which serves to automate the press operations. Normally placed on the press as chance permitted, various wiring and piping systems were difficult to trouble shoot and subject to damage during die changeover. New press line features a frame with built-in wires and piping, controls for press and automatic machinery, and automatic lubrication.

Additional feature of the new press lines is the conformance to standard dimensions developed by Joint Industries Conference for bolster, bed, die and slide area specification, and to blankholder and plunger dimensions. This makes possible, to a greater degree than before, interchangeability of dies between plants of one company and switchover of presses within plants in case of breakdowns.

Underdrive design of two of the six new lines is specially suited to modern plant construction involving low headroom for crane operations. Mounting the press drive beneath the floor not only reduces crown height and allows freer crane movements, it also puts maintenance and repair on the lower level and separates it from production line activity.

In designing these presses several objectives were stressed. Na-





CLEAN AND UNCLUTTERED exteriors of new press lines developed for automotive and appliance industries by E. W. Bliss Co. are typified by above illustrations. Anticipating the application of automatic materials handling equipment, Bliss has built into press uprights all controls, wiring, piping, and power and air line takeoffs necessary for automated press operation. Presses conform to specifications and dimensions recommended by Joint Industries Conference for bolster, bed, die and slide area, blankholders and plungers.

turally, a paramount consideration was the need for rugged structures and components to withstand round-the-clock production of heavy stampings. However, ease of maintenance was considered no less important. By working closely with production engineers at auto and appliance plants, Bliss designers were able to uncover many of the practical maintenance problems and eliminate their causes in the new designs.

INTERNATIONAL Business Machines Corp. has announced the appointment of **Dr. Cuthbert C. Hurd** as director of EDPM (electronic data processing machines). In his new post Dr. Hurd will co-ordinate

all of the company's engineering, manufacturing and product planing activities in the electronic data processing field. Dr. Hurd has been director of IBM's applied science division since it was established in 1949. He served as a technical research head at the Oak Ridge atomic energy facilities, is the author of two books and is a member of many scientific societies. He has studied at Drake University, Iowa State College and the University of Illinois.

Magnets Hold Pipe Securely

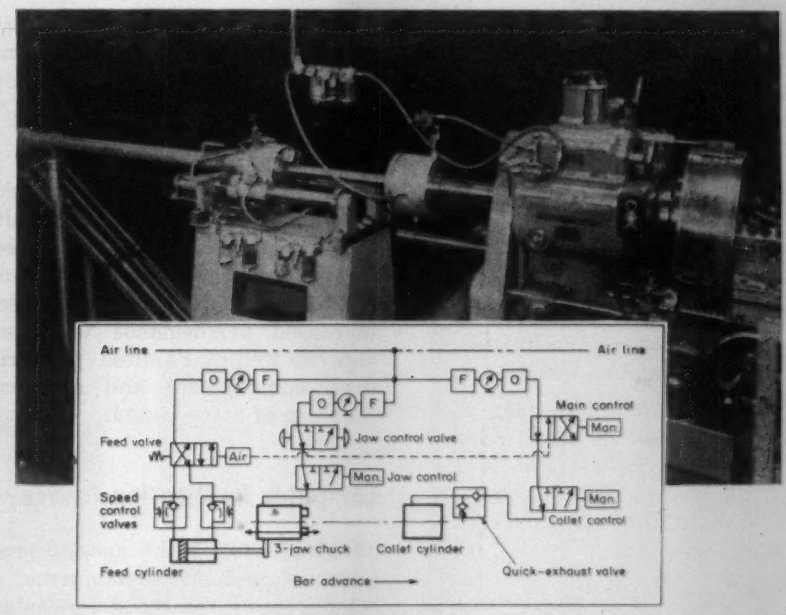
SAFETY AND CONTROL are the results announced by Eriez Mfg. Co. in the adaptation of nonelectric permanent magnets to certain pipe mill operations. Hold-down magnets are used to secure pipe undergoing hydrostatic testing. Defective pipe, which at rupture might otherwise be dangerously projected into the air by sudden force of water pressure, is firmly secured by the magnet. This type of fixture provides safety at low cost.

Addition of magnetic elements in rolls of conveyor are used to obtain control at such operations as cutoff, reaming and facing, coupling, threading and coating. Constant and secure hold on pipe permits maximum conveying speeds in ordinary conveyor application. To facilitate plant modernization, units are designed to match dimensions of existing nonmagnetic rolls. Magnets, unaffected by vibration, impact or extreme heat, are guaranteed to maintain magnetic strength indefinitely under normal use.

To Accent Industrial Packaging and Packing

INDUSTRIAL packaging and packing will receive more attention than ever before at the 1955 Conference of American Management Association's 24th National Packaging Exposition to be held in Chicago. According to **A. K. Thorn**, AMA packaging division manager, particular emphasis will be placed on the potential for greater efficiency and cost savings represented by the packaging of both customer and industrial goods. At concurrent sessions a number of specific areas will be explored in detail. These will include standardization, instrumentation, quality control, and the correlation of design in both the product and its package.

The conference also will stress the need for better integration of the packaging and marketing functions and for top management support of the packaging section. New materials, new packaging procedures, and new sales concepts will be described. Companies to be rep-



A new automatic bar feed and chucking system designed by Erickson Tool Co. converts a standard bar type turret lathe into a semi-automatic or fully automatic production setup. Use of a hollow precision rotating air cylinder for collet operation permits through-feed of bars. Feed chuck and collet air cylinder rotate with the stock. Stop collars on the guide tube provide proper feed length. Stock feed can be held within 1/64-inch.

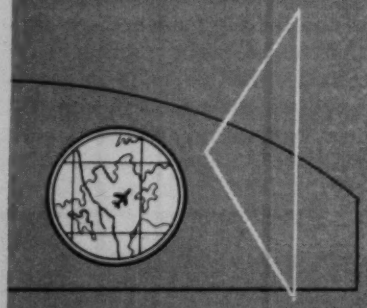
When main control valve is shifted to position shown in power circuit diagram, air fed to collet cylinder closes the collet. Air also shifts the automatic feed valve to position shown allowing feed cylinder to retract the 3-jaw chuck. On full reversal the chuck closes on the stock and machining begins. After machining and cut-off the main control is shifted, manually or automatically, exhausting air from the collet cylinder to open the collet and shifting the automatic feed valve to advance the bar whereupon the chuck opens for repetition of the cycle.

Stock may be loaded from the machine end of the bar feed, reducing space requirements considerably.

advanced technique

AVIONICS

fighter situation display by AVION



Fighter Situation Display (FSD) is an automatic, continuous indication on a map of the aircraft position during flight.

Developed by Avion for the Air Force, FSD eliminates manual computation and facilitates pin point navigation.

Avion's flexibility and ingenuity, coupled with extensive experience in Electronics, Mechanics and Optics can better serve you.

Investigate the career opportunities in our expanding organization.

AVION
INSTRUMENT CORP.
SUBSIDIARY OF ACF INDUSTRIES, INC.
299 Highway No. 17, Paramus, N.J.

resented on the program include U. S. Radiator Corp., Detroit; General Foods Corp., Hoboken, N. J.; and three divisions of General Motors Corp., the Ternstedt Div., Trenton, N. J., the Buick Div., Flint, Mich., and A. C. Spark Plug Div., Flint, Mich.

Conference will open at 10 a.m. Monday, April 18, and close after lunch on Wednesday, April 20. Tuesday and Wednesday sessions will begin at 9:30 a.m.; Monday and Tuesday sessions will close at 5 p.m.

Packaging Exposition is expected to set records for attendance, area and number of exhibitors. To date, more floor space has been reserved for exhibits than the total area occupied by last year's record breaking exposition.

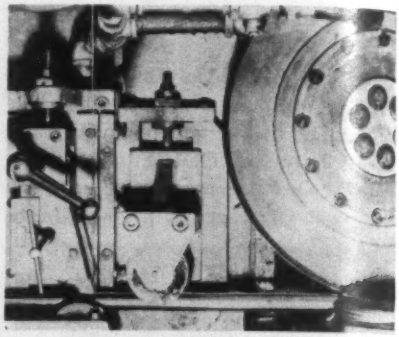
Improved Autopilot

NEW AUTOPILOT designed for supersonic aircraft has been announced by Lear Inc. Designated the L-10, the new flight control system meets latest military requirements with such features as automatic Mach-number control, automatic "G" control, and all-altitude maneuverability and control. The new autopilot has a lighter overall weight than its predecessor. Increased performance with savings in weight resulted primarily from compactness and multipurpose use of components.

Computer Application Course

TRANSLATING the special problems of industry, commerce or science into a numerical vocabulary for computers will be the subject of a two-week course to be held at Purdue University March 7-18. Course is sponsored by Electro-Data Corp. whose Datatron is the heart of Purdue's computer center.

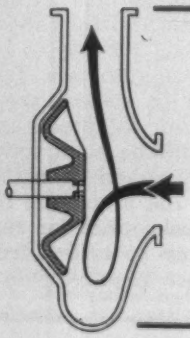
Before "graduating" each student can code, program, and actually run a problem in the field of his own choice—such as production scheduling, inventory, process control, cost accounting or product design.



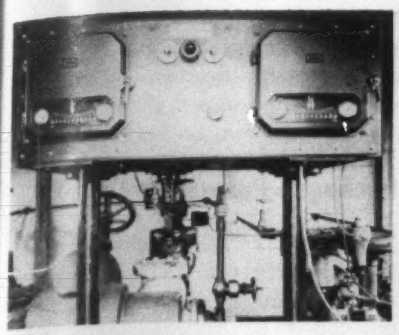
PROPER TOOL SPECIFICATION "made" this continuous tube-forming operation. Illustrated flash-trimming process—immediately after seamless welder and involving a continuous hot cut at speeds of 50-60 feet per minute—proved to be the trouble point before the proper tool was specified. Bissell Carpet Sweeper Co. and Carboloy engineers' solution to this problem now enables the company to use one trimming tool, without change, for an entire daily run of up to 13,000 feet of tubing for carpet sweeper handles.

More Time for Tea

SERIES OF TANKS, with appropriate rubber belt conveyor and controls, have been developed by Nucleonic and Radiographical Developments Ltd. of London for continuous processing of x-ray film. Variations in development time are allowed for by manual positioning of film in developing tank. Belt speed of 2 inches per minute carries the film automatically through remaining operations.



PUMPING anything from live goldfish to ready-mixed concrete has proved possible in test installations of a Wemco Torque-Flow Solids Pump, recently introduced by Western Machinery Co. Unit can pump fresh fruit from orchard to cannery without damaging it, move crushed ore pulp or ready mixed concrete without binding on large chunks or suffering wear at an excessive rate, and can pump waste material without clogging on rags, rope, string or rubber. New pump operates on a completely different materials moving principle as its impeller is similar to an automobile fluid drive and though entirely out of the material flow pattern, it induces a vortex (swirl) that does the pumping.

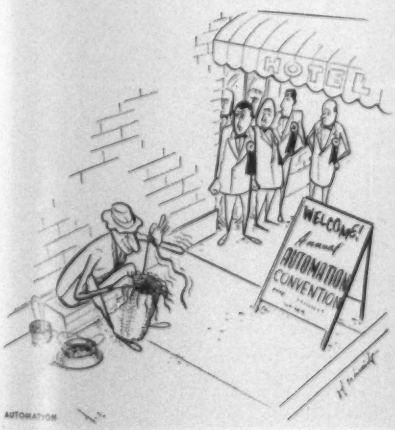


ELIMINATION of problems inherent in manual batch-blending of fuel oils to obtain No. 5 grade is made possible by this continuous, two component blender developed by Proportioneers Inc., a division of B.I.F. Industries. Operation of the blender is based on synchronization of flow of one component of the blend to output flow of the total blend. Predetermined control ratio, indicated by dial setting, is set manually. This blender is unique in that the use of reset type pneumatic controllers insures that the preset ratio will be maintained regardless of changes in system pressure. Unit is also suited for blending asphalt cutbacks, gasoline-butane and alcohol-water for direct product loading of motor transport.

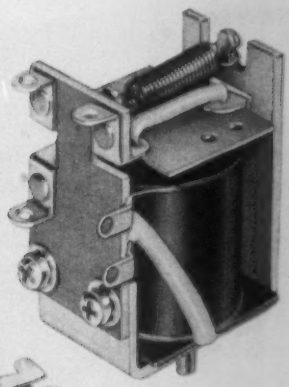
Pilot Operations Made Easy

ELECTRONIC testing system which will permit engineers to estimate the effect of adding new equipment to an industrial operation without actually test-installing such equipment, was recently announced by Minneapolis-Honeywell Regulator Co.

Known as a servoanalyzer, device automatically translates behavior characteristics of equipment to a chart record. This, in turn, is analyzed to determine how such a component will affect the overall behavior of operation. It is estimated that new system can save 30 to 60 per cent of the research



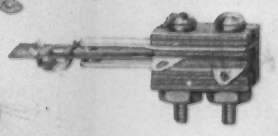
Good products deserve good components

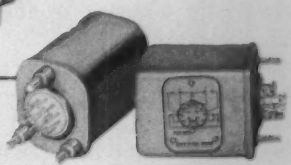


Comar components help good products perform better

If you use relays, solenoids, coils, transformers, or switches, in your product, your best source is Comar. Custom-manufactured to your specs, Comar components provide maximum efficiency and dependability at low cost. Send for full details now!

Visit Booth 314
The I. R. E. Show





Comar
ELECTRIC COMPANY
3349 ADDISON STREET
CHICAGO 18, ILLINOIS

RELAYS • SOLENOIDS • COILS • TRANSFORMERS • SWITCHES • HERMETIC SEALING

time involved in redesigning a process. It was initially developed by company engineers to meet their own needs for faster methods of equipment analysis, but is now being made available to industry.

In operation, the new system puts a control or a group of controls through their paces to see if they perform correctly when specific conditions are altered. This is accomplished by automatically introducing rhythmic change (similar to alternating current) into a process. Servo analyzer then automatically measures and plots effects. It can complete and record an entire test in as little as 8 minutes.

This portable system is made up of four components: a single generator, portable potentiometer, control box and a function plotter; and provides three forms of test energy: pneumatic, mechanical, and electrical.

Data Handling Equipment— A Must for Patent Processing

IN A RECENT ANNOUNCEMENT, Secretary of Commerce, **Sinclair Weeks,** made public the report of the Advisory Committee on Application of Machines to Patent Office Operations. Chairman of the committee is **Dr. Vannevar Bush,** president of the Carnegie Institute of Washington.

Committee recommended mechanization of the searching process in the U. S. Patent office as essential to the maintenance of an effective patent system. A second major recommendation stated that the National Bureau of Standards and the Patent Office should undertake a joint program to stimulate and develop machines and techniques specifically adapted to the Patent Office operation.

Because of the rapid scientific developments taking place, the committee said it would be unwise to attempt a transition to complete mechanization at this time. However, machine searching of compositions of matter should be put on an operational basis. Full application of mechanization would follow at some appropriate time after development of special studies.

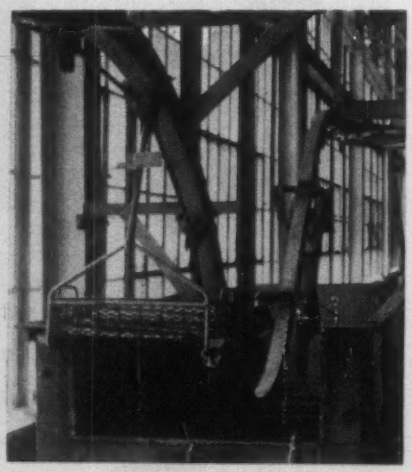
Attention was directed to the scope of the problem. The report stated: ". . . serious situation now facing the U. S. Patent Office is not being generally recognized. The office has a force of approximately 700 examiners struggling to keep abreast of these mountains of knowledge. Despite their efforts, there are more than 200,000 applications awaiting action, and the present staff is unable to keep the size of this backlog from increasing."

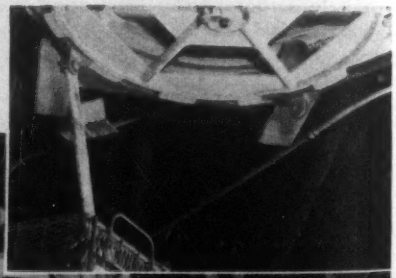
The search problem is "very critical" the report said. "It is so severe that conventional means offer little hope for adequate improvement. Fortunately, new developments in automatic information processing machines encourage a new approach. These machines offer a promise of rapid selection of the most appropriate patents, and also the possibility of a vast and never-failing memory of trails once pursued in a difficult search."

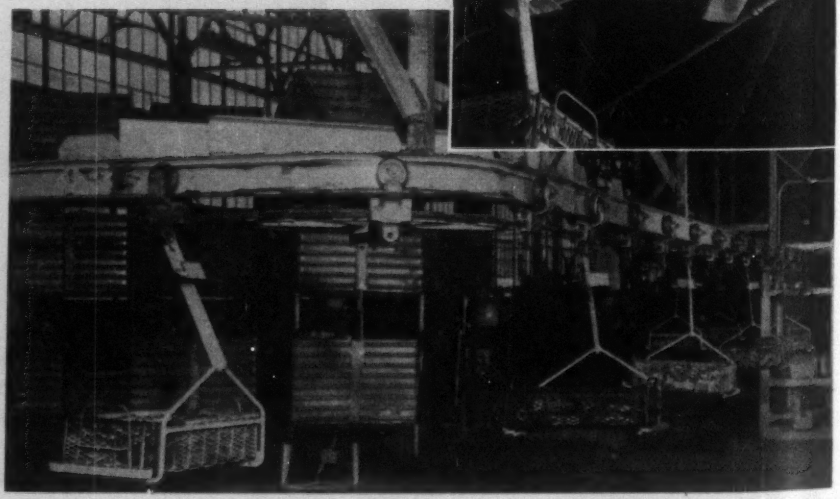
Packaged Pneumatic Tube Kit

MANUFACTURER of pneumatic tubes, conveyors and other material handling systems, Lamson has developed a prefabricated, 2-station pneumatic tube system, in kit form, that can be installed in any type of building by regular maintenance personnel.

By packaging the system, Lamson offers to industry the first pneumatic tube system available at equipment cost alone. The kit assembles into a two-way system connecting points up to 130 feet apart. Designed so that the user can lay out and install the equipment by following the simple instructions provided, it can be installed in a variety of configura-







STANDARD I-Beam monorail supports individual trolley brackets connected by segmented cable in this overhead conveyor system developed by Flex-I-Line Conveyor Corp. Trolley bracket spacing can be varied by changing cable lengths. Use of cable allows for greater flexibility in design of systems since sharper dips and turns can be obtained—note a degreasing operation involving dip at 60-degree angle and recovery at a 55-degree angle. Manufacturer has developed electronic load-unload stations and storage towers as accessories for a completely automatic conveying system. Inset illustrates details of drive at a 90-degree turn.

tions to connect points on either the same or different floor levels. Messages and other paperwork are moved through tubes in air-propelled carriers at a speed of approximately 20 feet per second.

RECENTLY APPOINTED to head research division of Texas Instruments Inc. is **Dr. Gordon K. Teal,** assistant vice president. In his new capacity he will now have charge of all research, involving work in many phases of electronics and

geophysics. Dr. Teal previously headed materials and components research department and has been prominent in the research and development of semiconductor devices — particularly transistors. Texas Instruments credits Dr. Teal with a major part in development of their position in the field of semiconductor manufacture.

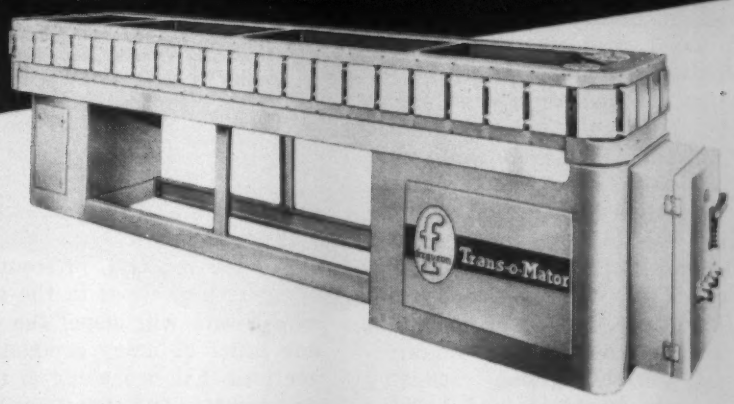
He acquired his doctorate at Brown University, was research associate in **Prof. Harold C. Urey's** laboratories at Columbia University, and associated with Bell Telephone Laboratories before joining Texas Instruments in 1953.

Defends Automation

CHARGES that increased use of automatic machines will prove harmful to labor were branded as dangerous thinking by **Haldon A. Leedy,** director of Armour Research Foundation of Illinois Institute of Technology.

Speaking at a meeting of the Chicago Chapter of Young Presidents, a group composed of leading young industrial executives, Leedy declared, "The spread of this type of thinking could result in disaster for the nation." He warned that the United States would be forced to take a back

STANDARDIZED AUTOMATION!



with STANDARD STRAIGHT LINE MACHINES FOR AUTOMATIC ASSEMBLY

THE FERGUSON Trans-o-Mator

★ *Reduces Manpower*
★ *Increases Production*
★ *Improves Product Quality*
★ *Cuts Maintenance*

THE TRANS-O-MATOR IS A STANDARD MACHINE

containing a complete power transmission unit, including motor, reducer, clutch, Ferguson Roller Gear Drive for high speed precision indexing, chain and carriers. There is an electrical interlock system between the indexing and the tooling power supply as well as start, stop and jog controls and provision for an automatic scanning device to insure proper function of all stations.

MECHANIZE YOUR MANUAL OPERATIONS

★ 20,000 pieces per hour ★ Tool and retool as required

SEND FOR COMPLETE CATALOG

SEE THE FERGUSON BOOTH #973 ASTE Show • Mar 14-18

Manufacturers of the Ferguson Trans-o-Mator, Ferguson Roller Gear Drives, Dial Feed Index Tables, Roll Feeds for Presses, Special Cams, Special Purpose Machinery.

ferguson

FERGUSON MACHINE & TOOL CO., INC.

ROLLER GEAR DIVISION, DEPT. AT-3 P. O. BOX 191, ST. LOUIS 21, MO.

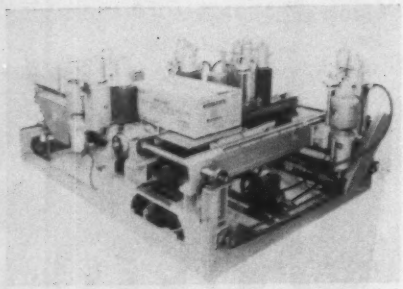
seat to Russia if anything was done to halt the further mechanization of the nation's factories and offices.

Forecast for Broaching

BRIGHT FUTURE for broaching machine manufacturers is predicted by **Arvid Lundell,** president of Colonial Broach Co. One reason for Lundell's optimism is that many additional metalworking companies will be able to take advantage of the efficiency possible with broaching operations because of new machines recently introduced plus those now in the design or development stage.

He reports that developments in broaching industry are two-directional: first, giving industry broaching machines and related equipment for automation lines and second, developing machines with greater flexibility for moderate run production.

Lundell predicts, "Recent developments plus those in the foreseeable future will dispel the erroneous belief of many production executives that broaching is too fast an operation and therefore does not fit directly into automatic production lines."



SAVINGS in inventory result from use of this case imprinting machine manufactured by Adolph Gottzcho Inc. Users carry an inventory of standard decorated cartons and with the Markoprinter add variable product information to the setup carton as they are packed. Design of the machine permits imprinting on four upright sides of the carton.

Pays for itself in Less than 100 days

FRIED Stripveyor Patented

makes sheet handling wholly mechanical

Automatically picks up cut strips, conveys them beyond shear bed. Makes shear 100% efficient. Adjustable to any height up to 45"—synchronous to shear speed—handles any gauge sheet up to 3/8", widths as wide as allowable by standard 20" back gauge, lengths to size of shear. Portable! Caster-supported carriage supplied with floor locks.

SHEAR TO .005"

FRIED Liftveyor Patented

Enables clean-cut wide shearing to .005" *regardless of material.* Eliminates flexing—supports sheet from underside while sheet edge is against back gauge—then conveys it beyond shear frame. For sheet or plate up to 3/8" thick.

For complete strip handling convenience add FRIED Strip-Stacker to Liftveyor or Stripveyor. Write for Bulletin FC-180

FRIED STEEL EQUIPMENT MFG. CORP.
528 EAST 119th ST., NEW YORK 35, N. Y.

MEETINGS AND EVENTS

Mar. 1-3—

Western Joint Computer Conference. Exhibition and conference to be held Hotel Statler, Los Angeles. Additional information may be obtained from William Gunning, 2000 Stoner Ave., Los Angeles 25.

Mar. 1-3—

Society of Automotive Engineers. Golden anniversary passenger car, body and materials meeting to be held Sheraton-Cadillac Hotel, Detroit. Additional information may be obtained from society headquarters, 29 West 39th St., New York 18.

Mar. 8-10—

Instrument Society of America. Instrumentation in iron and steel industry conference, sponsored by Pittsburgh section, to be held Hotel William Penn. Additional information may be obtained from A. F. Robins, Crucible Steel Co., Midland, Pa.

Mar. 14-15—

Steel Founders' Society. Annual meeting to be held Drake Hotel, Chicago. Additional information may be obtained from society headquarters, 920 Midland Bldg., Cleveland.

Mar. 14-18—

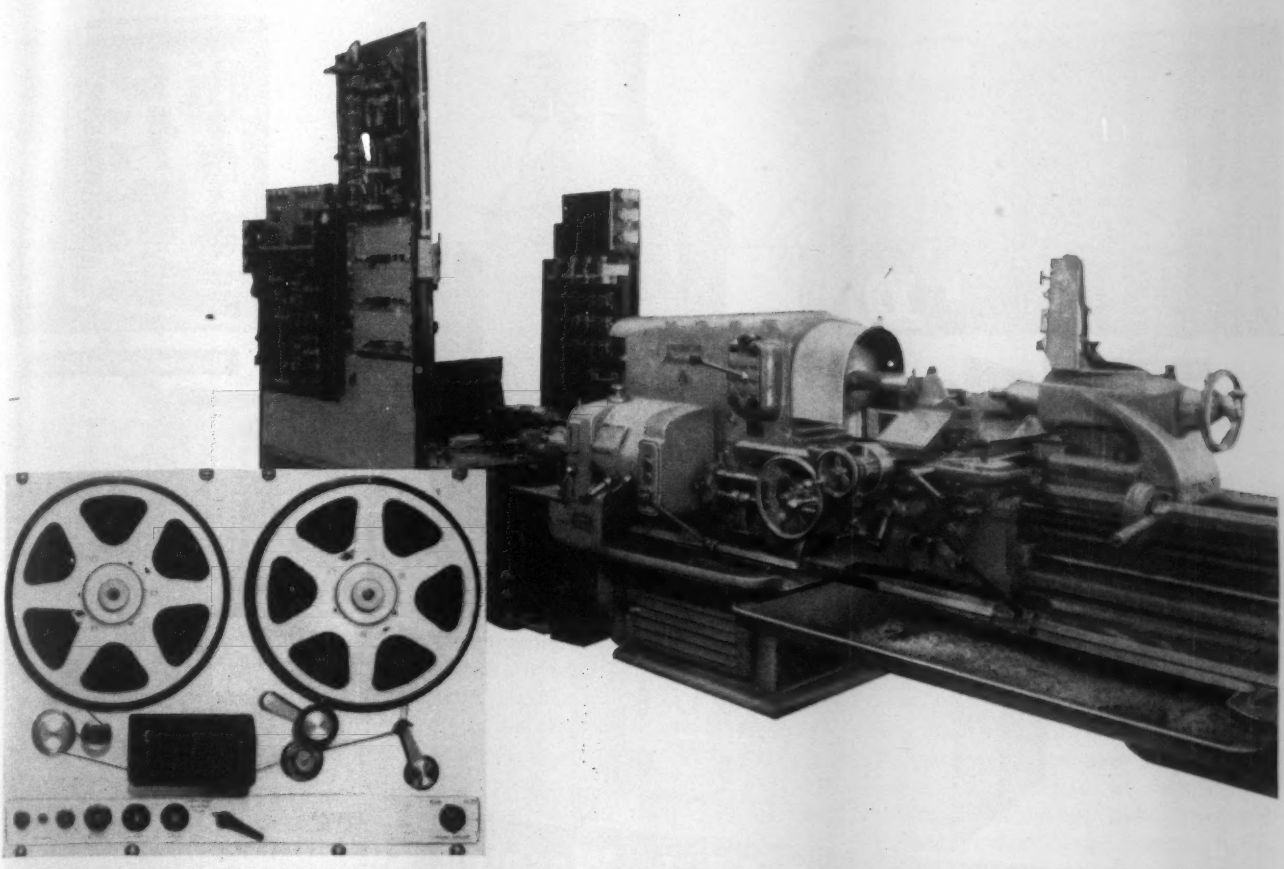
American Society of Tool Engineers. Western industrial exposition to be held Shrine Exposition Hall, Los Angeles. Additional information may be obtained from society headquarters, 10700 Puritan Ave., Detroit 38.

Mar. 16-18—

Pressed Metal Institute. Annual spring technical meeting to be held Hotel Carter, Cleveland. Additional information may be obtained from institute office, 2860 E. 130th St., Cleveland.

Mar. 21-24—

Institute of Radio Engineers. National convention and radio engineering show to be held Waldorf-Astoria Hotel and Kingsbridge Armory, New York. Additional information may be obtained from institute office, 1 East 79th St., New York.



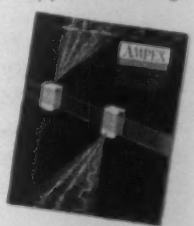
MAGNETIC TAPE CONTROLS MACHINES LIKE THIS

An Ampex Magnetic Tape Recorder programmed all operations of this 16" lathe. The Ampex machine was selected by General Electric, who designed and built the control system, to provide the "memory" which helped guide the machine flawlessly through the accurate motions involved in machining irregular parts. For each part to be manufactured, a skilled machinist made the first unit. The Ampex recorder "remembered" his motions and could thereafter direct the lathe in the manufacture of one part or a thousand — now or twenty years from now.

Other exacting work programs of drilling, jig boring, tapping, or gear cutting can be converted into electrical signals by existing tracer techniques . . . and permanently recorded on magnetic tape. The control system using the memory characteristics of this tape can give you an exact duplication of the original work sequence, again and again . . . wherever and whenever you want it. **Result:** machine tool setup time is shortened . . . print reading and "miking" times are reduced . . . operator errors and rejects are eliminated . . . and simultaneous operation of two or more feeds, on two or more machines is possible.

For Your Automation Needs: **Ampex Precision and Durability**

Ampex recorders retain precision even after thousands of hours of use. And they can be adapted to almost any automation need. Let our application engineers determine whether magnetic tape can provide a more efficient control system for your operation — or write for our 16-page bulletin on "Data Recording, Machine Control and Process Regulation."



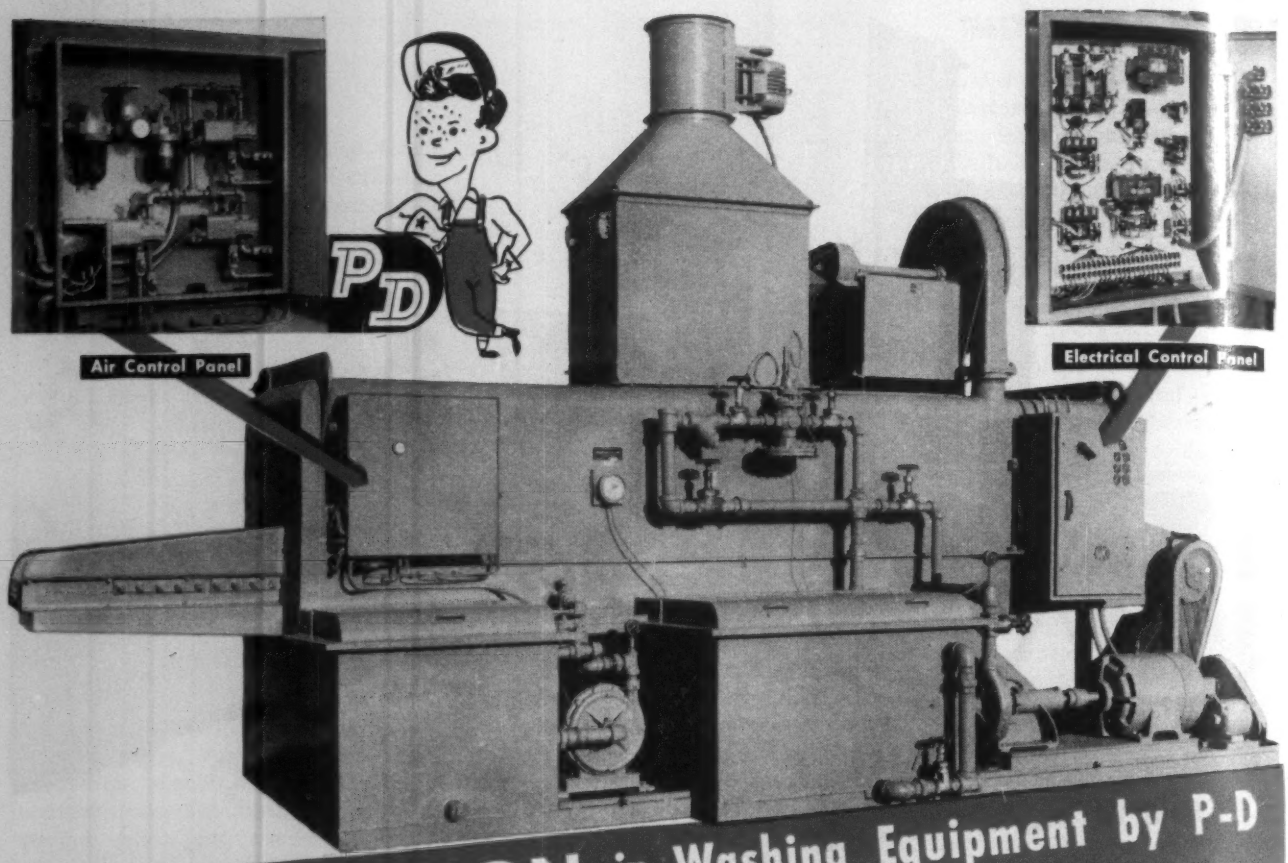
AMPEX CORPORATION

Signature of Perfection in Magnetic Recorders

Contact your nearest Ampex representative or write — wire Dep. **DD-1896**

AMPEX CORPORATION • 934 CHARTER STREET, REDWOOD CITY, CALIFORNIA

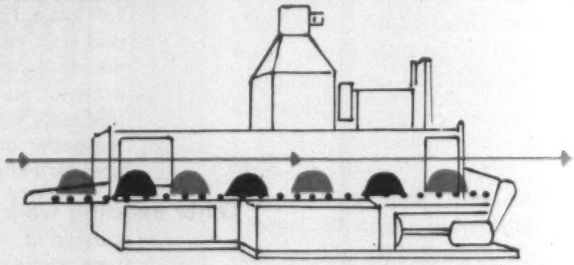
Branch Offices: New York; Chicago; Atlanta; San Francisco; College Park, Maryland (Washington D.C. area).
Distributors: Radio Shack, Boston; Bing Crosby Enterprises, Los Angeles; Southwestern Engineering & Equipment, Dallas and Houston; Canadian General Electric Company, Canada.



AUTOMATION in Washing Equipment by P-D

(Above photograph is of a 3-Stage Washer for Torque Converter Housings)

Many important production problems are met and solved by this Power Spray Washer—designed, engineered, and built by Peters-Dalton. It meets the full meaning of the newly coined word "automation" by eliminating many processes that were formerly manual or handled through separate facilities.



Extremely efficient, time-saving, and economical in operation is the action of this 3-Stage Washer. It sprays both the inside and outside of converter housings. The operation is done in a continuous action—first, the housings are fed to the machine on gravity rolls—then an air cylinder moves each over the inside spray manifold. This same motion holds back the unit following and moves the preceding unit onto a cross-rod conveyor for outside wash. Another cylinder positions each unit over the manifold and blocks the shaft opening. The inside and outside wash are both heated emulsified oil cleaners—room air blow-off removes excess oil. The exhaust has an eliminator and a filter box for entrapping overspray.

Whatever your problems are for washing products during your manufacturing process, count on Peters-Dalton for the correct solution. Peters-Dalton is an organization of specialists—staffed by men who KNOW the answers. Washers of all sizes, types and required uses can be developed to meet your needs — whether from a single unit or to a complete installation — depend on P-D to give the services and production you have the right to expect. We invite inquiries—Just Write, Wire or Phone.

Ask for our new Power Spray Washer Tech. Bulletin No. 301.

Peters-Dalton INC.
17894 Ryan Road • Detroit 12, Michigan

- *Hydro-Whirl Paint Spray Booths*
- *Industrial Washing Equipment*
- *Drying and Baking Ovens*
- *Hydro-Whirl Dust Collecting Systems*

DETROIT DATELINE

By FLOYD G. LAWRENCE, Detroit Editor

AUTOMATION DOLLARS AND SENSE

AUTOMATION to the man in the street derives the prefix "auto" from the four-wheeled vehicles of the same name rather than from the Greek *"autos"* meaning "self."

That's not unnatural since the auto industry typifies mass production in this country and gave birth to the term *automation*. Certainly in physical scope and economic impact the auto industry deserves that association. And in a business that has been bitterly competitive since it was cranked up, technological progress has been the key to survival.

Yet, to the casual student of such matters, a good case can be built up against automation ever getting a solenoid inside an auto company door. That's because automakers deal in a product with perishable virtues. The fender that curves down today will curve up tomorrow and the windshield that wraps around tomorrow will be swept back the day after.

Because such a healthy segment of the automakers' tooling falls into disdain with last year's models, on the surface it might appear that trying to automate an auto plant is like trying to take a nap on an escalator.

Although you might presume the automakers had a pinky in the materials handling business, automation obviously carries its freight or it wouldn't go in. The three basic criteria are initial cost, reliability of the equipment and savings resulting from automation. Taking them one at a time, here roughly is the basic reasoning process the automakers use in deciding whether or not to automate.

Selection of the types of automation best suited for the operation to be performed are compared with the conventional equipment in installation and operating cost. This isolates the amount which could be charged directly to automation, but that's only part of the story. Automation is only as valuable as the reliability of the machines, and it's interesting to note in that regard that there is a trend among automakers away from the more complex pieces of equipment toward the simply constructed units tied together with automation.

Less spectacular than the complex jobs in appearance, the integrated units are more spectacular in production figures. Simple design is helping the automaker avoid being "caught with his plants down" which brings us to the third factor, savings possible through automation.

Bill Newberg, president of the Dodge Div., Chrysler Corp., explained these points at a recent SAE meeting. He feels that nowhere is there more misunderstanding than in the evaluation of the amount of money that can be saved through automation. This, he says, is because few realize where the savings from automation really lie.

For example, many kinds of automation might be rejected because they do not promise a net reduction in manpower. Yet they might be most profitable if considered from the standpoint of safety, savings in floor space, improvements in quality, lower production costs, improved working conditions or increased production.

Improvement in quality often is the best single justification for automation in competitive businesses. Quality advantages in a machine that can only do its work one way are obvious, and lower production costs are equally obvious as a result of traditional increases in output and reductions in manpower. Also pretty obvious is the improvement in working conditions for the man who now operates the machine rather than acting as virtually a part of it.

Another key factor in justification of automation is the increased production. That arises from the fact that through well-designed materials handling the load and unload time of the machine is reduced, normally permitting about 80-90 per cent of the time to be spent in actual machining. Increased production, along with quality, are probably the two most important basic factors in automation in the auto industry though any of the factors mentioned can be more important, depending on circumstances.

Automation in the auto industry is not without its problems. Designing mechanical production aids which can handle next year's parts as well as those of today is a problem. Although much equipment can be amortized over a period as long as five or ten years, a great deal more must be written off in one year.

But the automakers aren't paying for automation; automation is paying for them. In succeeding columns we'll be taking a closer look at the why's and wherefore's.

● The majority of America's homes must be rebuilt or remodeled. Sixty-seven percent of homes are now over twenty years old; fifty percent are over thirty years old. Since 1950, three million new homes have been built but the population has increased by nine million and continues to increase. *The prediction for 1955 — one million, three hundred thousand homes — an increase of 100,000 over 1954.*

Homes require great tonnages of steel, copper, brass, aluminum, other metals, rubber and plastic. Construction and equipment of a modern six-room house may take up to 7,000 pounds of steel alone, plus tonnages of other metals and materials.

Are your plants equipped to meet volume demands at proper cost or are you losing sales position by inefficient, high-cost equipment? Good equipment brings down production costs.

This Continuous Butt Weld Pipe Mill produces ½" to 1½" pipe up to 1,250 feet per minute. How does this speed compare to the speed of your pipe mill? In addition to pipe and tube mills, Aetna makes other basic machines for producing, processing and fabricating steel, copper, brass, aluminum, rubber and plastic, including: Continuous Coating Lines, Rolls, Flat-Rolled Finishing Equipment, Drawbenches and related equipment; Machinery for Rubber and Plastic.

Good equipment keeps down production costs.

SUBSIDIARY and ASSOCIATED COMPANIES

Head Wrightson Machine Company, Ltd., Middlesbrough, England — Great Britain, Finland, Sweden, Norway, Denmark, Union of South Africa, Northern and Southern Rhodesia.
Aetna-Standard Engineering Company, Ltd., Toronto, Ontario, Canada.
M. Castellvi, Inc., New York, N. Y. — Mexico, Central and South America.
Societe de Constructions de Montbard, Paris, France — France, Belgium, Holland, Luxembourg, Switzerland.
Demag Aktiengesellschaft, Duisburg, Germany — Germany, Austria, Yugoslavia, Greece, Turkey, Egypt.
Compagnia Italiana Forme Acciaio, Milano, Italy — Italy.
Aetna-Japan Company, Ltd., Tokyo, Japan — Japan.
Hale & Kullgren, Inc., Akron, Ohio — Representative for the Rubber Industry.
Standard Engineering Company, Ellwood City, Pa.
Trans-World Traders, Pittsburgh, Pa.

Designers and Builders to the Ferrous, Non-Ferrous, Leather, Rubber, and Plastic Industries

THE AETNA-STANDARD ENGINEERING COMPANY • PITTSBURGH, PA.

Aetna-Standard

PLANTS IN WARREN, OHIO • ELLWOOD CITY, PENNSYLVANIA

GOOD EQUIPMENT BRINGS DOWN PRODUCTION COSTS

Answer for Tomorrow

With an eye to the future, the question often arises as to the real necessity of automation. Is it just a fad? Is it only a matter of "keeping up with the Jones'" in some manufacturing circles? Or perhaps, is it only one rather questionable means of meeting competition under difficult circumstances?

Far from it! Automation today offers the only practical key to maintaining our present high level standard of living and promises much in the way of even greater advance. For practical reasons why, it is only necessary to consider first one important factor—present trends in population.

Dr. Gordon W. McKinley, chief economist of Prudential Insurance Co. of America, points out that the population by 1965 will reach some 190 million persons, an increase of 30 million over today's level. He predicts that gross national product will reach $540 billion compared with the $356 billion level of 1954. To fulfill this more than 50 per cent increase in demand, only about 18 per cent increase in labor force will be available—persons under 18 years of age together with those 65 and over will account for roughly 44 per cent of the population.

The answer? Automation will provide the increased productivity necessary to meet these needs and at the same time make possible Dr. McKinley's predicted 25 per cent increase in personal income of workers.

The great advance in recent years of management, semi-skilled and skilled occupations will accelerate. Need for engineers will multiply tremendously because automation creates unprecedented demands for better design of product, better engineering of machines and systems, and better maintenance in operations.

Perhaps such forecasts sound somewhat over-optimistic and the figures hard to believe. In terms of the past, they are, but in terms of today's potential they are not only possible but well within practical range. The goal is high but with reasonable effort and co-operation, attainment is well within our grasp.

EDITOR

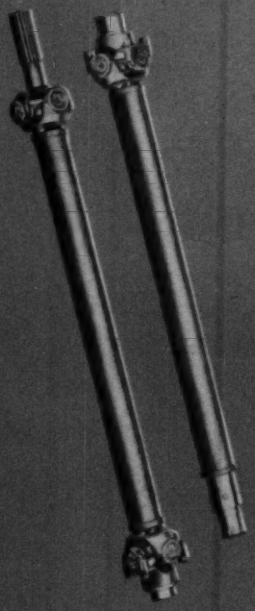
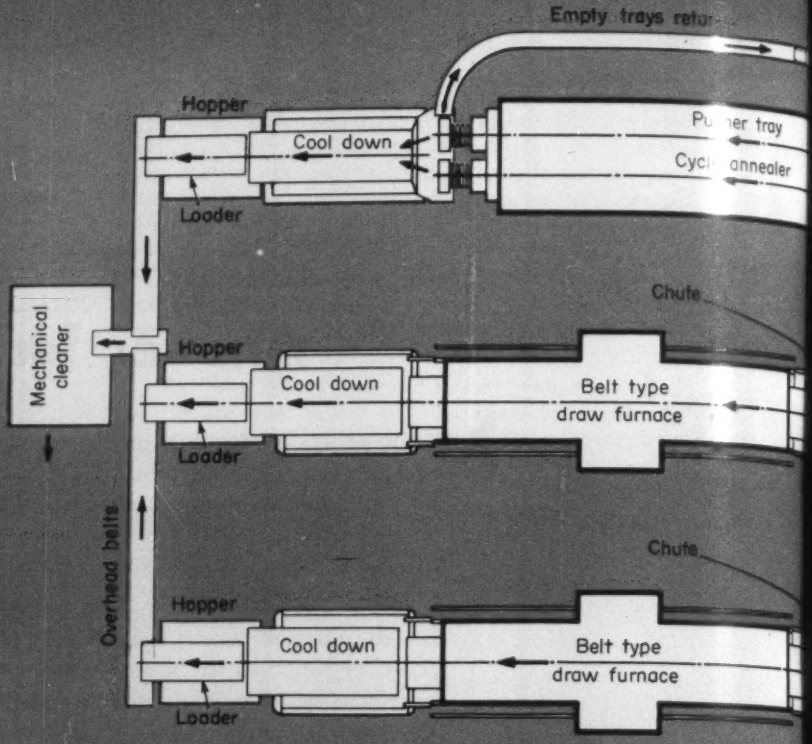
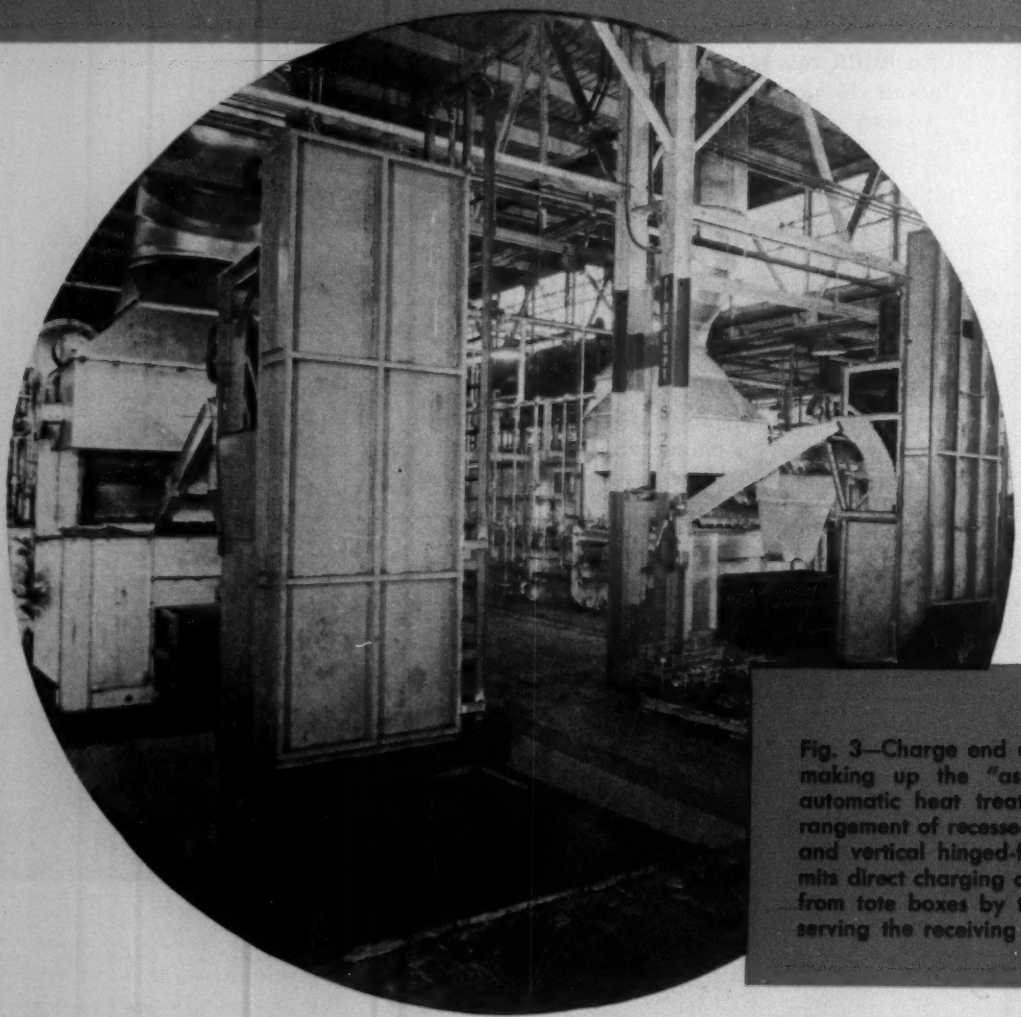


Fig. 1—Typical universal joint and propeller shaft assemblies produced in a range of sizes by Marion Mfg. Div., Dana Corp.





By W. J. BEHRENS
Chief Metallurgist
Marion Mfg. Div., Dana Corp.
Marion, Ind.

Fig. 3—Charge end of the furnace lines making up the "as received" forging automatic heat treat facility. This arrangement of recessed floor level hopper and vertical hinged-flight conveyor permits direct charging of each furnace line from tote boxes by the overhead crane serving the receiving and storage areas

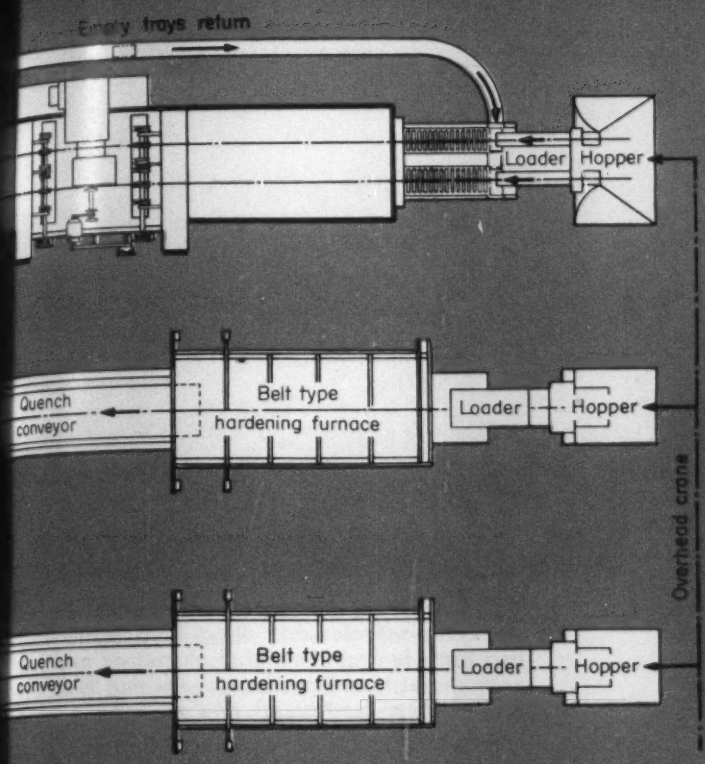
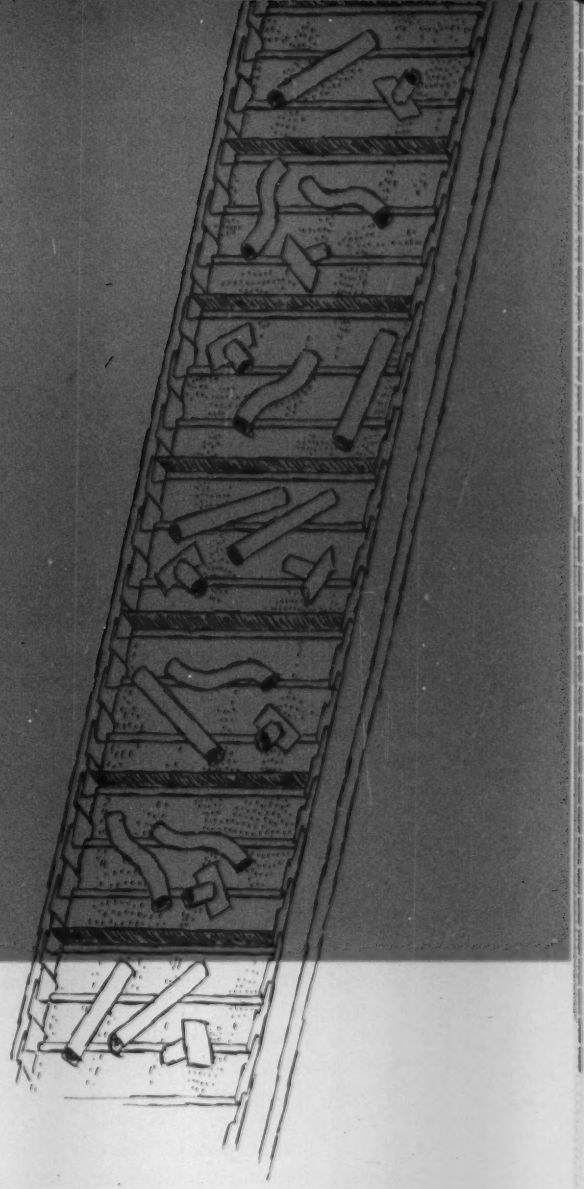


Fig. 2—Floor plan of "as received" forging heat treat area showing the cycle annealer and harden and draw lines all automatically tied into a mechanical cleaning operation



CONTINUOUS HEAT TREATING

FOR AUTOMATIC PRODUCTION

Eliminating conventional heat treat room and incorporating furnaces as part of the automatic production line, cuts out excess handling, increases production rates, and makes possible, closer control of processing—all fundamental factors contributing to quality manufacturing

MODERN CONTINUOUS heat treat furnaces, due to design adaptability to accommodate all types of parts of different shapes and sizes, and all methods of material movement, have literally moved from the conventional heat treat department right into the production line. Here they function in essence as machines in the line which, for mass production of automotive parts, is becoming more automatic every day. Production equipment today, although in many instances previously automatic and self-contained units, is now being effectively interlocked with other machines by automatic material handling facilities to create completely automatic processing from raw material to finished parts—automation.

One of the new automotive parts plants, the Marion Mfg. Div., Dana Corp. is a good example

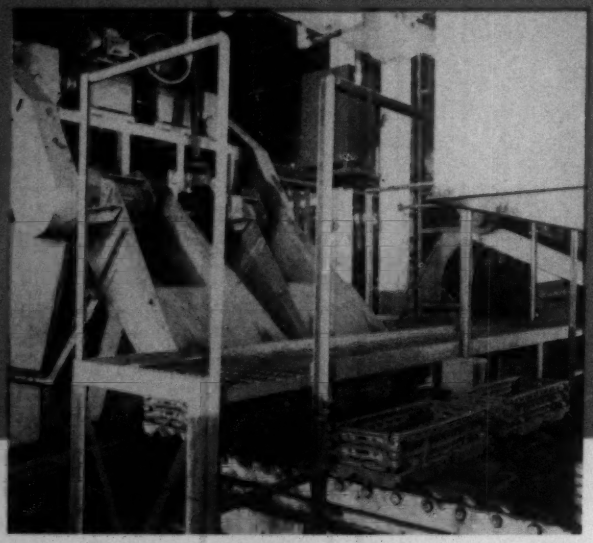


Fig. 4—Charge end of direct-fired cycle annealer showing automatic basket loader. Empty baskets are moved from discharge end to charge end by a chain conveyor. Parts are fed automatically to baskets in sequence as empty ones are moved into position

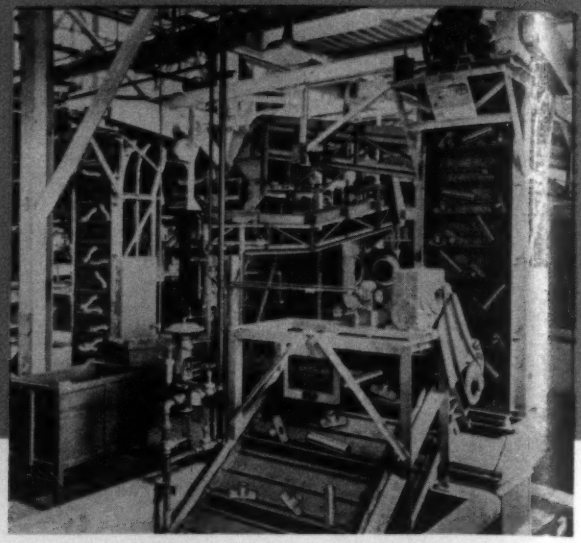


Fig. 5—Discharge conveyor arrangement on the cycle annealer and direct fired harden and draw furnaces consisting of inclined and vertical slat type hinged conveyors that feed a blast type mechanical cleaner

of this trend. Basic parts production for the automotive universal joint and propeller shaft assemblies, *Fig.* 1, manufactured in this plant is carried out on an automatic basis. Each individual part has its own processing line. Where heat treatments of any kind are involved, except for the treatment of "as received" forgings and for tool room operations, the furnaces are incorporated in the automatic production line. In this manner, gas-fired continuous furnaces of the belt, pusher tray, rotary retort, overhead pusher, and barrel type are used in automation applications. This heat treat equipment was designed and built by Surface Combustion Corp., Toledo, Ohio.

▶ Centralized "As Received" Treating

The heat treatments such as annealing, hardening and drawing, which are required for forgings in the "as received" condition, are carried out in one area near the receiving docks. A pusher type cycle annealer and several belt type harden and draw lines are all automatically tied-in to a mechanical cleaning operation by an overhead handling system, *Fig.* 2.

At the charge end of each furnace line, a combination of recessed floor level hopper and vertical hinged-flight conveyor is provided for automatic charging. This arrangement, *Fig.* 3, permits the receiving dock overhead crane to charge the recessed hopper direct from tote boxes. Parts are lifted from the hopper by the vertical conveyor and dropped at specified intervals onto the belts of the harden and draw furnace lines. The cycle annealer trays, *Fig.* 4, are also automatically loaded, in sequence, two at a time by the same type of loading arrangement.

The automatic arrangement at the discharge end of each furnace line, *Fig.* 5, incorporates a combination of inclined and vertical, slat type hinge conveyors that automatically remove the parts from the cool-down water quench, and deposit them on a system of overhead interchange belt conveyors feeding the mechanical blast cleaner. All of the furnace lines feed the cleaner interchangeably, or at the same time. Cleaner has a capacity of 7000 pounds per hour. After the parts are cleaned, they are sorted and deposited in tote boxes according to type.

▶ Treating Cycles

The direct gas-fired cycle annealer is of the two-row pusher tray type. It isothermally anneals forgings of SAE 8617H, 1117 and 1137 steels at the rate of 2000 pounds per hour. A typical ten hour complete cycle involves heating to 1630-1680F followed by a fast cool to 1200 F holding at this temperature and a discharge into water heated to 200 F. The cool-down operation is used on the forging heat treat lines in order to minimize shock of quenching into water and to gain a dry part that is clean of loose scale. The resulting hardness ranges from 143 to 179 brinell depending on the steel.

Direct-fired harden and draw lines are of the continuous conveyor belt type. They are used for hardening forgings of SAE 1140 and 1137 steels

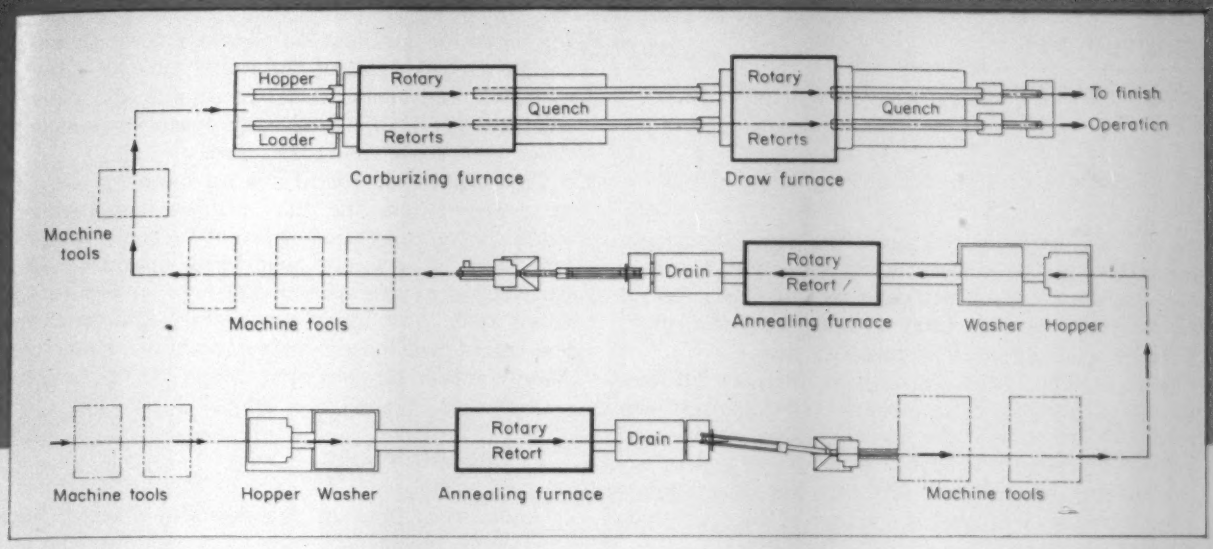


Fig. 6—Schematic flow of the automatic production line for bearing races with integrated press forming, machining, annealing, washing, carburizing, and grinding operations

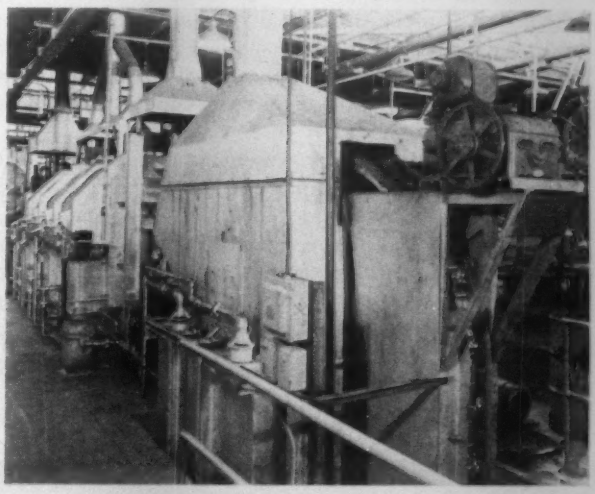


Fig. 7—View of rotary retort controlled atmosphere furnaces used for annealing between mechanical deep drawing operations. Note washer in foreground with automatic feeder

using either of two standard heat treat cycles. Both cycles involve heating to 1580-1630 F followed by a quench into water held at 100-150 F. After the quench the cycle varies. Parts are drawn at either 900-1200 F or 1100-1300 F, depending on requirements. Hardness after the draw reads about 229 to 285 brinell. Capacities of these belt furnaces are as high as 3000 pounds per hour, depending on size of part.

The belt furnaces also incorporate the same type of cool-down water quench as used on the cycle annealer. Another unique arrangement on the belt furnaces is an automatic scale remover operating in the quench tank between the harden and draw furnaces. A hair pin shaped tube with openings for picking up scale, contains a continuous internal chain with flights. These flights lift accumulated scale from the bottom of the quench tank and deposit it in containers at floor level. Continued operation has shown that it is necessary to operate the remover only about 16 per cent of the time.

▶ Integrated Operations

Individual parts requiring heat treating and mechanical forming and other operations are produced on automatic lines that integrate all required units of processing equipment, including the heat treat furnaces.

The bearing races require several anneals between deep drawing and machining operations which are followed by gas carburizing and final grinding. The entire operation is automatic with the equipment laid out as shown schematically in *Fig.* 6. The raw material is first press formed, machined, washed, annealed, washed, press deep drawn, washed, annealed the second time, washed, machined, gas carburized, water quenched, tempered, cooled down in soluble oil and moved to final grind.

Movement between each piece of machinery can be completely automatic and all furnace charging carried out through hoppers equipped with metering devices and charging mechanisms. By building up charges in these hoppers, any variations in flow from machine tools, and other equipment will not interrupt regular flow of parts required to keep the furnaces operating at peak capacity.

Rotating retort controlled atmosphere furnaces.

Fig. 7, are used for the annealing and carburizing operations. The single retort annealing furnaces are equipped with direct gas-fired burners situated above and below the alloy retort. Only the retort is filled with prepared atmosphere gas.

The double retort carburizing furnace utilizes gas-fired suction type radiant tube heating elements. The tubes are also situated above and below the retort. Prepared atmosphere gas in the carburizing furnace not only fills the retort but is also introduced around the retort in the gas tight heating chamber.

DX (exothermic) prepared atmosphere gas is used for surface protection during the annealing operations. The bearing races, produced of SAE 1016 steel, attain a work hardness of about 85-90 Rockwell B after the initial mechanical deep drawing. An anneal at 1350 F reduces this hardness to 50-60 Rockwell B for subsequent forming. The annealing furnaces each have a capacity of up to 400 pounds per hour.

The carburizing furnace, utilizing enriched *RX* generator gas, in both retorts, carburizes steel parts to a total case depth of 0.040-0.045 inch after five to six hours time in the carburizing atmosphere at temperature. Surface carbon concentration averages about 1.0 per cent. After a water quench, the parts are automatically passed through a tempering furnace, also of the retort type, and heated to 325 F and cooled down in soluble oil. Surface hardness after this tempering operation is usually from 60-63 Rockwell C, file hard.

This particular facility is an excellent example of a production line that utilizes dispersed-integration of a number of different furnaces each carrying out a separate heat treat operation. The furnaces are interspersed between numerous machine tools and other processing equipment and the entire installation integrated into a single completely automatic operation.

Line After Line

Another method of furnace and machine integration in this modern new plant involves the utilization of several complete self-contained heat treat lines tied into an automatic continuous production line. In this case the furnaces function as the last phase in the overall cycle, *Fig.* 8.

The operations preceding heat treatment include several rough machining and finish machining operations on the small, but complicated journal crosses. This is followed by a wash before feeding to the furnaces. Feeding of parts is accomplished by an arrangement of conveyor, hopper and special device that meters parts to a vibratory feeder at any desired rate, *Fig.* 9. These devices serve to convert a variable rate from the machining operations to a steady rate that is ideal for the most efficient furnace utilization.

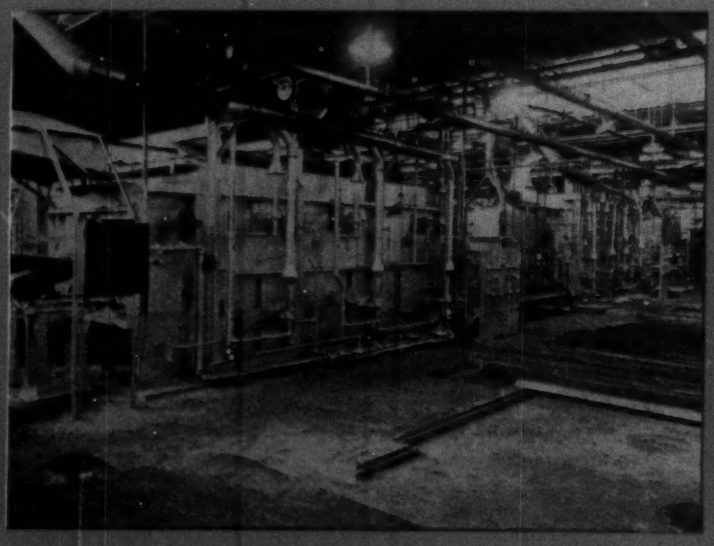


Fig. 8—Overall view of the three self-contained rotary retort controlled atmosphere heat treat furnaces that function as the final processing phase of the production line making journal crosses

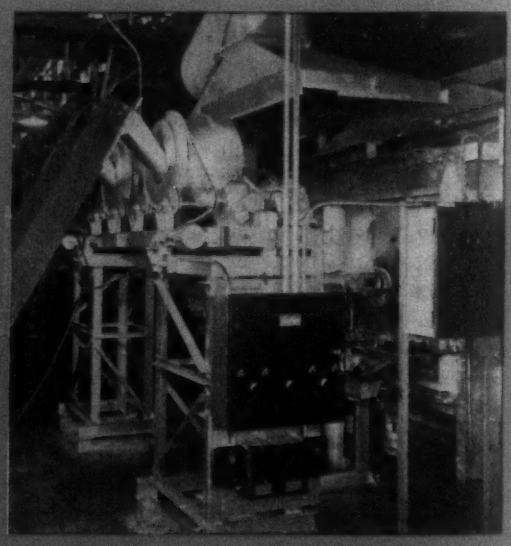


Fig. 9—Charge end of journal cross furnace line showing arrangement of belt conveyor, metering device and vibratory feeder introducing parts to the rotating retorts at desired rate

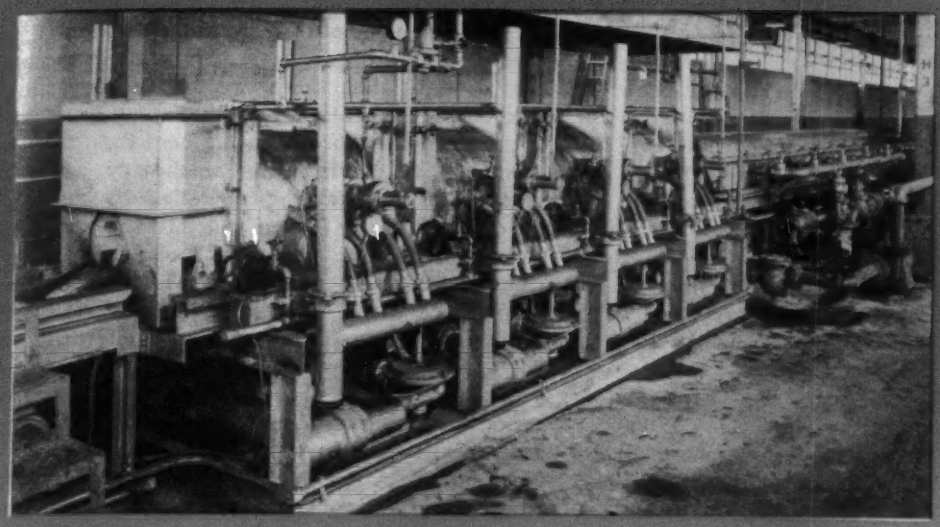


Fig. 10—Barrel type high speed gas-fired furnace maintains a heating chamber temperature up to 2600F while the parts being heated leave this chamber at a temperature of 500-700 F

The metering device operates on the basic principle of a beam scale and meters the parts according to an adjustable weight setting on the scale beam. A time clock with two scale settings is used. The first scale permits automatic transfer of specified amounts of parts from a hopper or other work handling arrangement into the rotating drum device. The other scale regulates the feeding rate, to the furnace, of the drum and vibrating transfer mechanism that operate as a single unit.

Journal crosses and other parts are made of SAE 1117 and 8617H steel. They are initially carburized in enriched *RX* generator gas atmosphere, remaining in the carburizing furnace for about 8 hours to achieve a total case depth of 0.050 to 0.060-inch with a surface carbon concentration of 1.0 per cent. Temperature is in the 1700 F range. After carburizing, the parts are dumped into oil for a cool-down quench, withdrawn by a single retort to the washer and then reheated to 1580 F in a retort furnace of the same design type as the carburizing furnace. After two hours in this furnace, they can be quenched in either oil or water, as desired, rewashed and given a final temper at 325 F for about one hour. Total time in passing through these furnaces usually requires around 12 hours. Final hardness is between 59 to 62 Rockwell C, file hard. Production rates from the furnace line are up to 500 lb per hour.

▸ Single Furnace Fits Into Line

Continuous straight-line production requiring only a few similar operations and a single heat processing operation are also carried out in this plant. Tubes are produced for the shaft of the propeller shaft assemblies. On the tube production line, strip steel is automatically uncoiled, roll formed, welded, cut to size, trimmed, passed through a high-speed gas furnace for strain aging followed by a water cool-down quench. A rust-proofing solution is used for the cooling. Finished parts are then automatically racked for the next phase in production processing.

The high thermal head furnace utilized in this line is of the barrel type with tangential-firing gas burners, *Fig.* 10. The temperature inside the heating chamber reaches as high as 2600 F while the parts, traveling through this chamber at up to 120 feet per minute are only heated to 550-700 F. The ability to heat at this high speed permits the integration of this furnace in the automatic line as the pace setter rather than the weak link in the line.

▸ Central Control A Prime Necessity

Since these heat treat furnaces are widely dispersed throughout the plant, central control of operations is maintained at the metallurgical laboratory.

The metallurgy department in this plant functions on the furnace equipment in essentially the same capacity as a set-up man does on a machining line. This group is responsible for operation of the equipment and control of the metallurgical cycles and material specification tolerances. To facilitate control of dispersed equipment, a central trouble-panel is used, *Fig.* 11.

This L-shaped control indicating panel is connected to all of the individual drive mechanisms for pumps, fans, conveyors, ignition systems, etc., on

each furnace and prepared atmosphere generator. While the green light is burning, the drive mechanism is operating satisfactorily. When the companion red light goes on, followed by an audible signal, trouble of some kind has interrupted operation of the drive or power mechanism. In full operation, this panel is hooked up to 13 continuous furnace lines plus two individual furnaces and six prepared atmosphere generators.

The prepared atmosphere generators of the endothermic type (*RX* gas) and exothermic type (*DX* gas) are located at one central point directly behind this panel. The prepared atmosphere gases are manifolded and piped directly from this point to each controlled atmosphere furnace. When "enriching" additions are required for gas carburizing, they are made at each furnace as required. To facilitate this operation, the mixer, valves and controls are mounted on a central panel conveniently located next to the furnace.

All temperature indicating and controlling instruments of the potentiometer type are also centrally located in a special air conditioned room next to the metallurgical laboratory. Each instrument is clearly identified as to the furnace or generator that it controls. The recording and indicating charts face the control room windows. This permits visual checking of the instruments without entering the air conditioned room.

Considerations and Conclusions

The basic methods used in this plant include the incorporation of a single continuous type heat treat furnace, a number of differnt furnaces at separate points on the line and the utilization of an automatic self-contained heat treat line at some point within a production line.

The result of this unique procedure can be the highest quality production and maximum production rates due to the elimination of excess handling, and the closer control of processing through elimination of the human element. It must be remembered, though, that there are certain limitations worthy of consideration in planning an automatic production facility incorporating heat treat furnace equipment. By moving this machinery which is especially designed for the controlled dispensing of heat, out of a central room and into the proximity of conventional metal-forming machinery, inexperienced personnel are being affected. Their lack of experience with this type of equipment accents the possible unfamiliarity of personnel with conditions involving higher ambient temperatures, gaseous atmospheres and unusual noises. Adequate training and indoctrination programs should be provided to alleviate this situation.

The equipment must also be laid out for best location of utility connections, pump, piping, etc., to keep areas around equipment free of unnecessary hinderances that might prevent ready access for inspection and maintenance. Considerations must also be given to shielding close-working presonnel from hot doors, chutes, flue ducts from burners and any radiating heat. Safety systems and, where possible, standby facilities assure continued furnace operation in case of utility interruptions.

Finally, the most important requirement for successful operation of an automatic system that is process or plant-wide, is *uniformity*. Raw material must be uniform and of optimum quality. Equipment must also be uniformly dependable and efficient in operation.

Mass production operations under automatic control cannot be economically varied. The material analysis and physical properties must be exactly the same every time. The furnace cycles and other machine tool operations cannot be altered for every heat of steel. This situation presents a challenge to suppliers of equipment and raw materials if automatic production is to increase in scope and application in our present expanding economy with its ever increasing demand for goods.

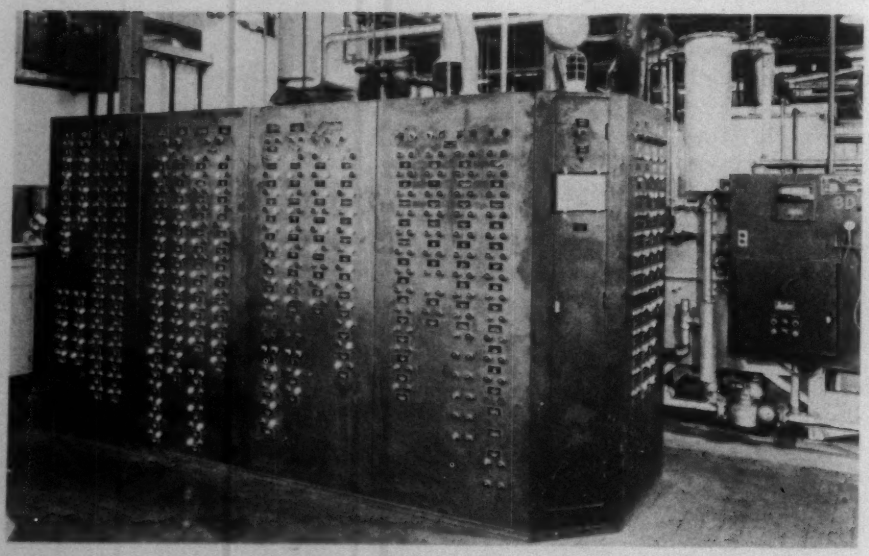
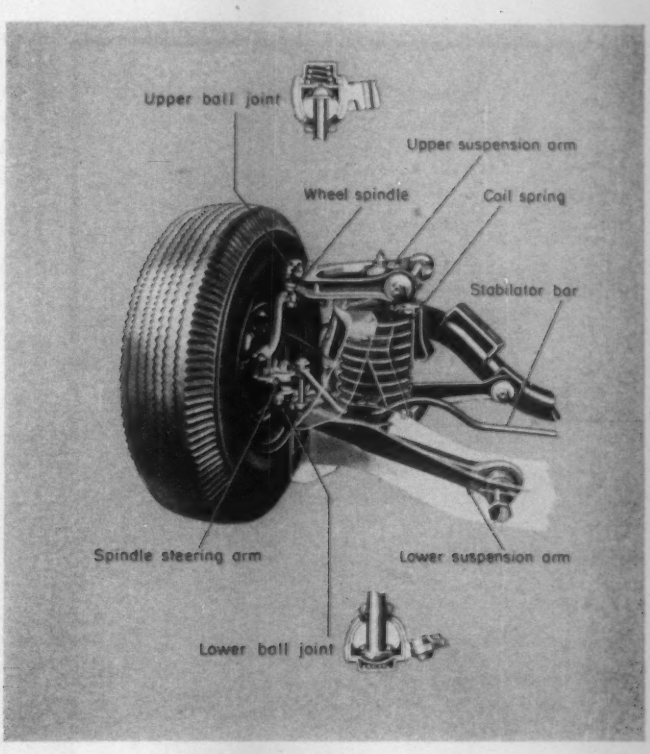


Fig. 11—This L-shaped central furnace and generator operating panel is situated in the metallurgical laboratory area. Separate lights for each individual drive mechanism on the furnaces indicate satisfactory operation, or that trouble of some kind has interrupted the drive mechanism



1

Details of the automobile ball joint front suspension. Machining of the upper ball joint casting and the lower ball joint casting is accomplished simultaneously in the fifteen station transfer machine described herewith.

AUTOMATION TODAY

TRANSFER MACHINING

BALL JOINT front suspension parts for Canadian built Monarch and Mercury automobiles are being produced in the Windsor, Ontario plant of the Ford Motor Co. of Canada, Ltd. Long recognized as a cornerstone of the automotive industry's trend toward automation, the transfer machine here plays a major role in the machining of these parts.

An upper and a lower ball joint casting are each loaded into each fixture, which is in turn transferred through the fifteen stations of the machine and returned by conveyor to the loading position. This machine, which was designed and built by Modern Tool Works, Ltd. of Toronto, Ontario, consists of five identical basic sections connected by hardened dovetail ways on which the fixtures slide. Each base carries its portion of the transfer bar and the cam bar for actuating fixture locating pins. These bars and ways are joined to form the main base of the machine.

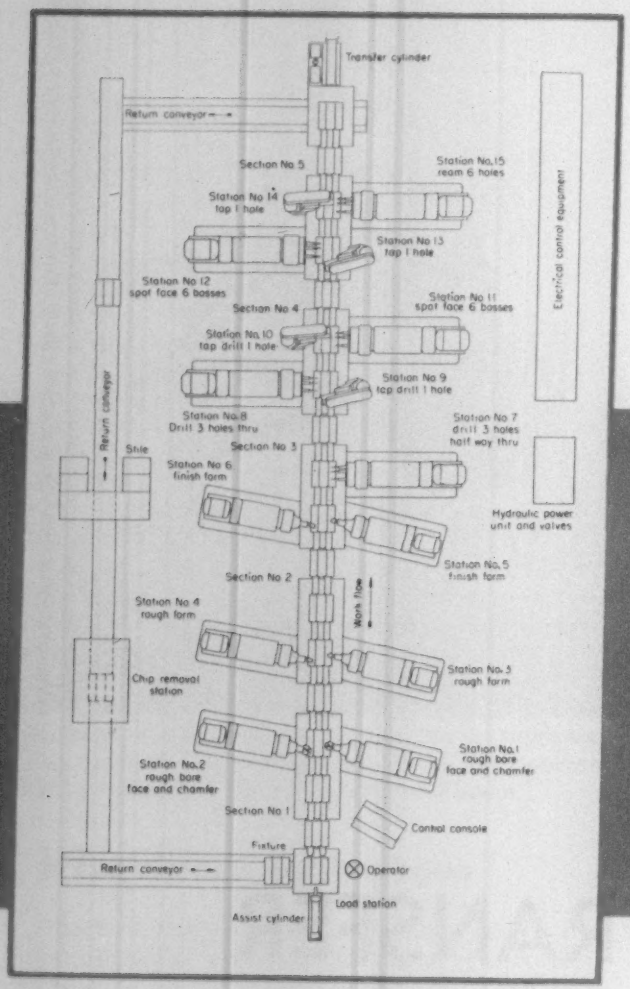
Each side of the base castings is machined to permit the mounting of work stations at any position on these faces. The use of standard self-contained hydraulically operated machining units, electrically interlocked, provides a unitized construction that has accessibility and flexibility in the event of a product design change.

Signal lights on the pushbutton panel at the operator's station indicate failure of any of the principal functions of the machine. The operations consist of loading, boring, facing, chamfering, forming, drilling, spotfacing, reaming, and tapping. Should the machine be stopped part way through an automatic cycle, all work units that have started their cut will automatically back out of the work before coming to a complete stop. Those units that have not completed their work will advance again and finish the cuts before another index can take place.

Chips are removed from the work stations by a drag type chip conveyor. As each fixture is moved to the loading station on the return conveyor it

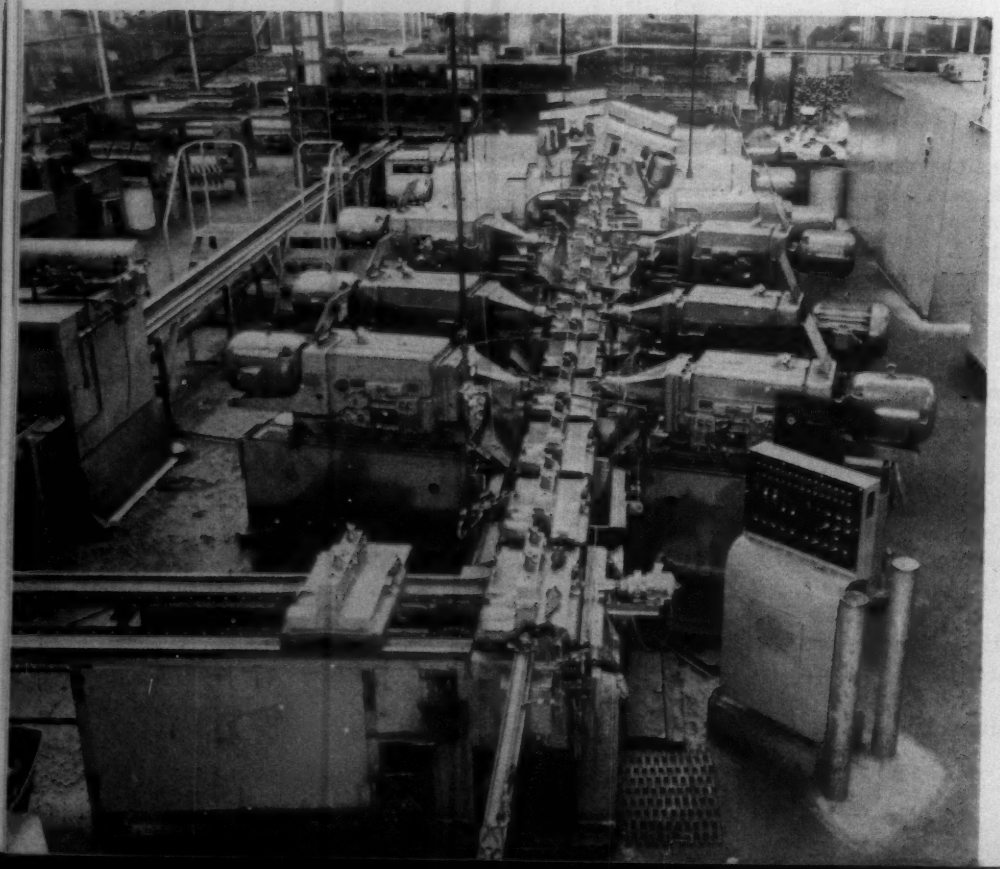
passes through the chip removal station where cuttings and coolant are automatically removed by blasts of compressed air. Electrical control equipment is panel mounted in an enclosed cabinet. Another cabinet houses the hydraulic power unit and valves.

This type of transfer machine arrangement illustrates the adaptability of these principles to the machining of small parts.


Transfer cylinder
Return conveyor
Section No 5
Station No.15 ream 6 holes
Station No 14 tap 1 hole
Station No 13 tap 1 hole
Station No 12 spot face 6 bosses
Section No 4
Station No 11 spot face 6 bosses
Station No 10 tap drill 1 hole
Station No 9 tap drill 1 hole
Station No.8 Drill 3 holes thru
Station No 7 drill 3 holes half way thru
Stile
Section No 3
Station No 6 finish form
Hydraulic power unit and valves
Station No.5 finish form
Section No 2
Work flow
Station No 4 rough form
Station No.3 rough form
Chip removal station
Station No.1 rough bore face and chamfer
Station No.2 rough bore face and chamfer
Section No 1
Control console
Fixture
Operator
Load station
Assist cylinder
Electrical control equipment

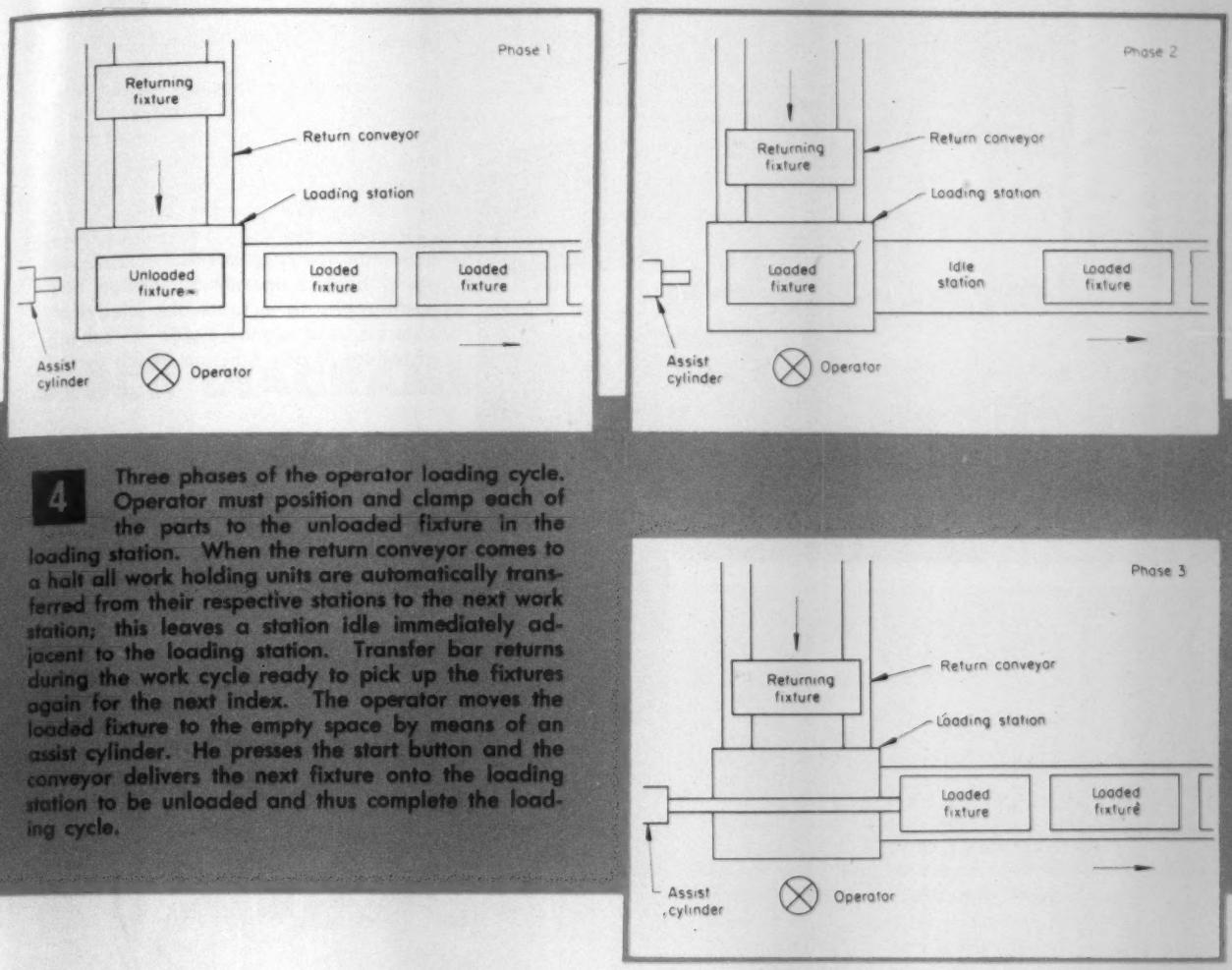
2

Floor plan of the system shows unitized construction consisting of five standard base sections connected end to end and tooling stations mounted on each side of these bases. In the event of a redesign of the product other standard workheads can be mounted where no station now exists or additional section bases can be added at the end of the line. Design of such a layout gives consideration to spacing between these standard self-powered machining units so that ample room is provided for changing cutters and maintenance of the equipment.



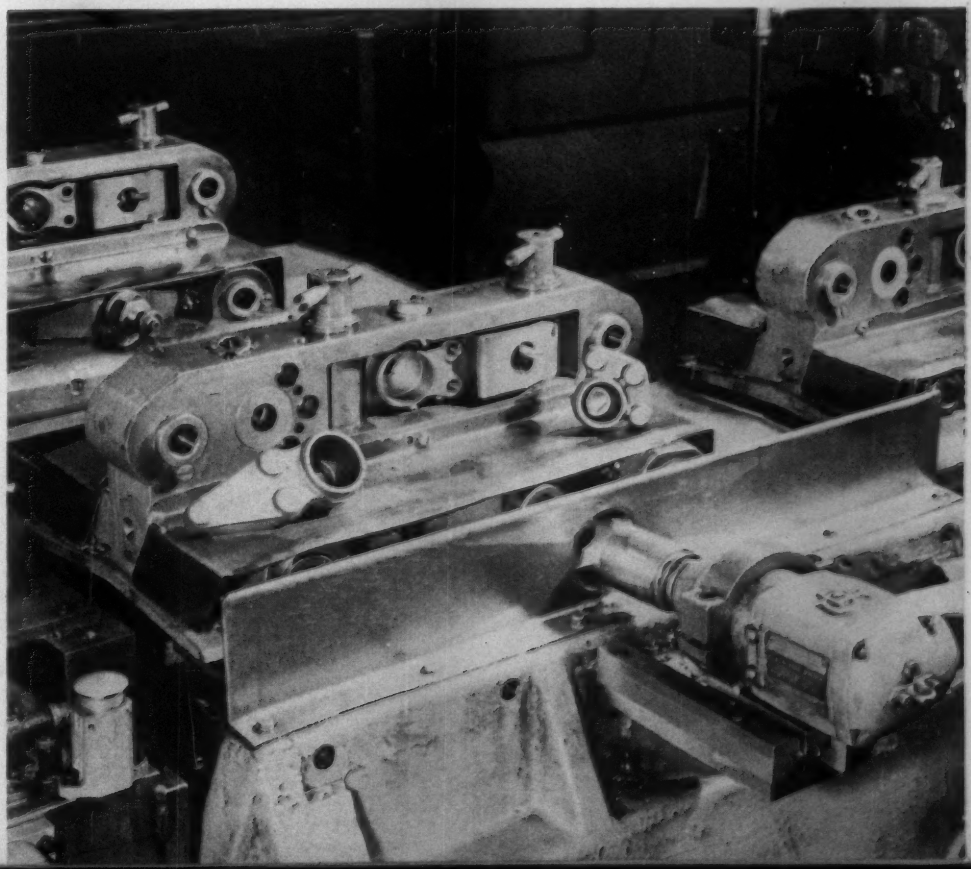
3

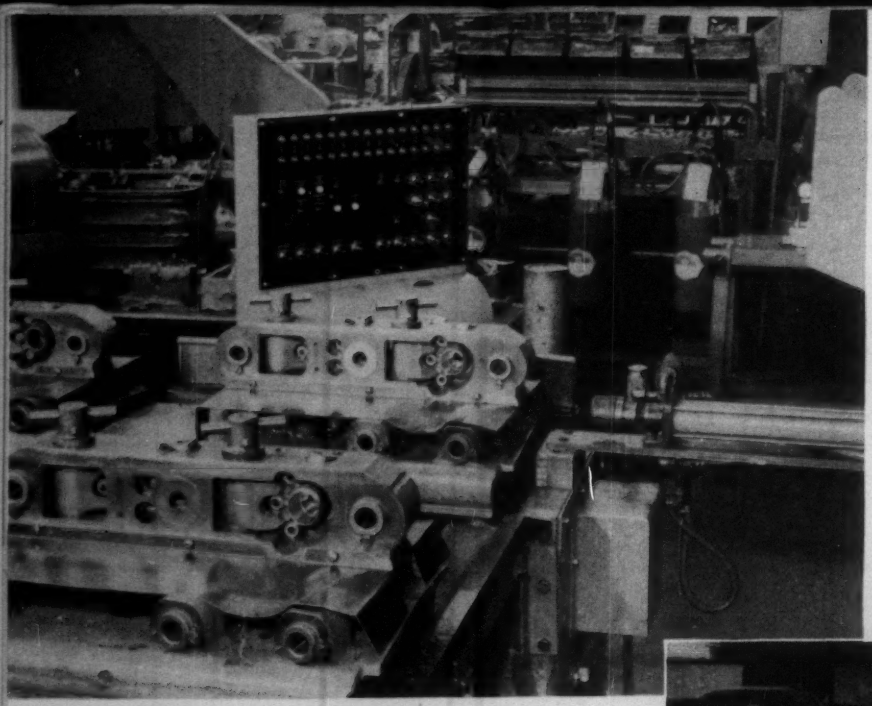
General view of the transfer machine installation. Operator's loading station is in the foreground. At the start of the cycle all tooling stations move into the fixtures and perform their cutting operations. When workheads are back at rest the transfer bar moves all fixtures simultaneously to the next work station where they are automatically clamped and the cycle begins again. To maintain this cycling the operator must load one fixture per cycle and see that it is in position for the transfer bar to engage. The action of this transfer bar delivers one fixture off the end of the line each cycle. Return conveyor on the left delivers completed work back to the operator.



4 Three phases of the operator loading cycle. Operator must position and clamp each of the parts to the unloaded fixture in the loading station. When the return conveyor comes to a halt all work holding units are automatically transferred from their respective stations to the next work station; this leaves a station idle immediately adjacent to the loading station. Transfer bar returns during the work cycle ready to pick up the fixtures again for the next index. The operator moves the loaded fixture to the empty space by means of an assist cylinder. He presses the start button and the conveyor delivers the next fixture onto the loading station to be unloaded and thus complete the loading cycle.

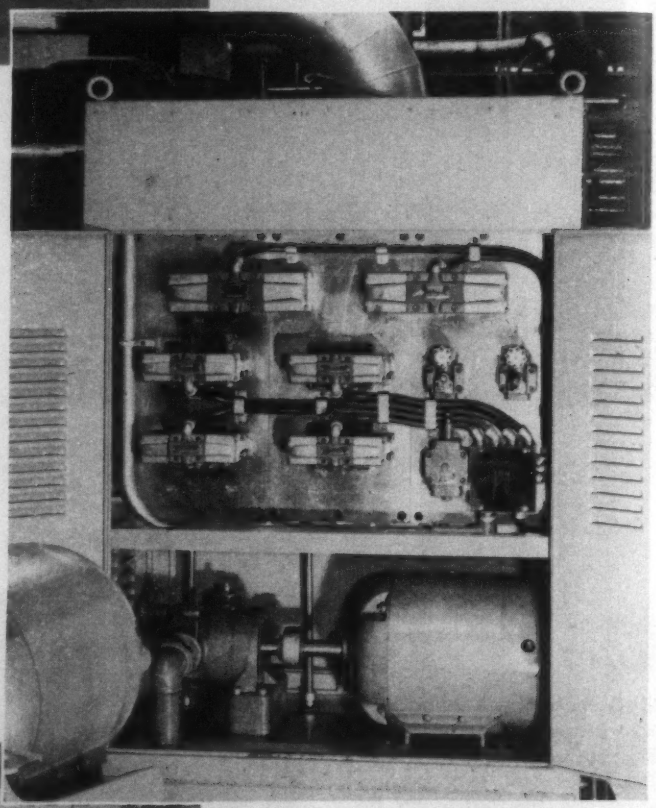
5 Close-up of the loading station shows the fixture with finished parts still in place. The lower ball joint casting shown on the left is to be loaded into the right side of the fixture, while the casting on the right will be loaded from the rear into the left side of the fixture. The air-operated power wrench mounted in the foreground is used by the operator to engage a nut in the base of the fixture and clamp the workpieces in place. Guide bushings are provided to locate the workheads and cutting tools accurately with respect to the fixture, thus providing for alignment at each machining station.





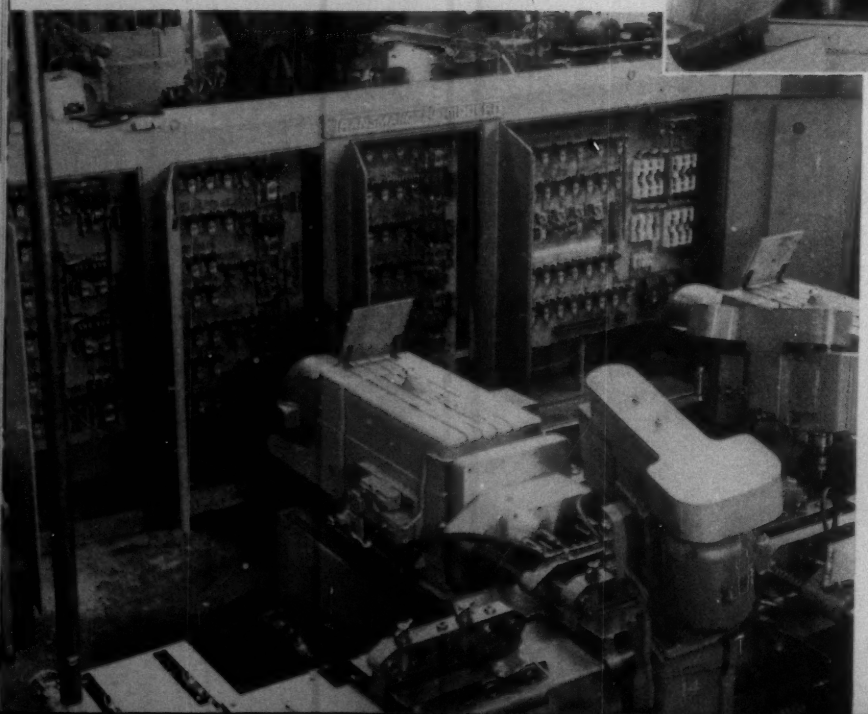
6

Rear view of the loading station pictured in *Fig. 5*. Two fixtures in center have finished parts returning from end of line. Fixture at left has raw castings and is in the first position for pickup by the transfer bar. Assist cylinder on the right moves the fixture from the loading position. Console panel behind operator's position has pushbuttons to actuate the electrical controls and signal lights to advise of failure of any function of the cycle.



7

Hydraulic power units with panel-mounted solenoid valves are designed into a single compact cabinet. The valves are gasket mounted, and steel tubing and fittings are used throughout to conform to JIC standards. This cabinet is mounted an aisle space away from the main machine as may be seen in Fig. 2



8

Enclosure for the electrical control equipment contains the interlocking circuitry that provides continuous automatic operation and safety for the entire installation. Standard work-spindle unit of the last station of the machine illustrates details of horizontally mounted special multiple drill-heads with spring loaded bushing plates that engage the fixture to provide rigidity and alignment for the machining operation.

Eighth of a series, AUTOMATION presents the final section of the ASME standard "Automatic Control Terminology"; an original work of the Terminology Committee of the Industrial Instruments and Regulators Division. It is hoped these data sheets will assist in furthering the adoption of a standardized language in the field of automatic control.

BLOCK DIAGRAMS, SYMBOLS, AND CONTROL COMBINATIONS

BLOCK DIAGRAMS

In section 100 there was shown a block diagram of an automatic controller and its feedback loop. There are many occasions where it will be found convenient to use a block diagram of a system to indicate its functioning and the section which follows discusses very briefly the considerations underlying the construction of block diagrams and their associated symbols.

Fig. 1 shows the circuit schematic for a vacuum tube amplifier and *Fig.* 2 shows the schematic of pneumatic amplifier or relay. Both of these amplifiers may be represented by the block diagram of *Fig.* 3. The lines of the block diagram of *Fig.* 3 denote flow of information, the arrows represent the direction of flow and the block represents the function or dynamic characteristics of its components.

As various blocks are combined by lines it is sometimes necessary to indicate arithmetic manipulation. This is done by means of the special junction point blocks shown in *Figs.* 4 and 4*a*.

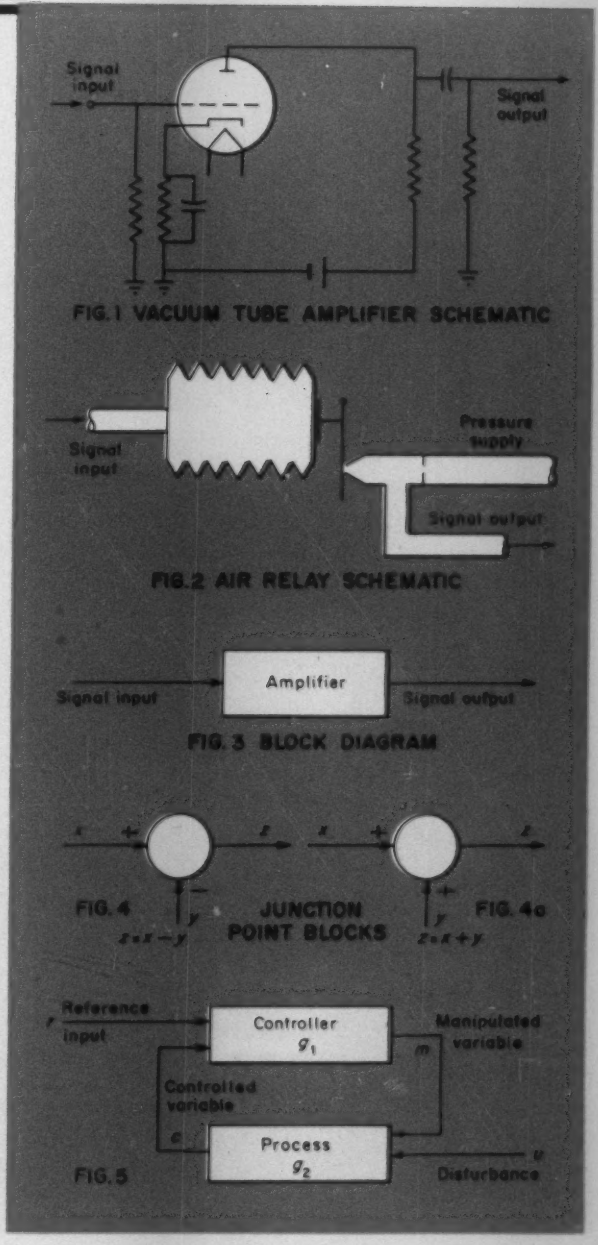
The equations accompanying the diagram explain the operations involved. Note that the information flowing to and from a given junction point must all be expressed in the same unit. This is not necessary in the use of other blocks such as shown in *Fig.* 3. The summing points of *Fig.* 4, 4*a* are extended to include the addition of more than two variables by merely adding more arrows to the circle with the proper sign. The sign may be omitted if it is not significant to the analysis.

SYMBOLS

In the case of the blocks it is necessary to have certain symbols which define the block operations associated with it. Some of the more common symbols follow:

Actuating signal	e
Control elements	g_1
Controlled variable	c
Disturbance	u
Feedback elements	h
Manipulated variable	m
Primary feedback	b
Process (controlled system)	g_2
Reference input	r
Reference input elements	a
Set point	v

With the foregoing in mind a condensed block diagram



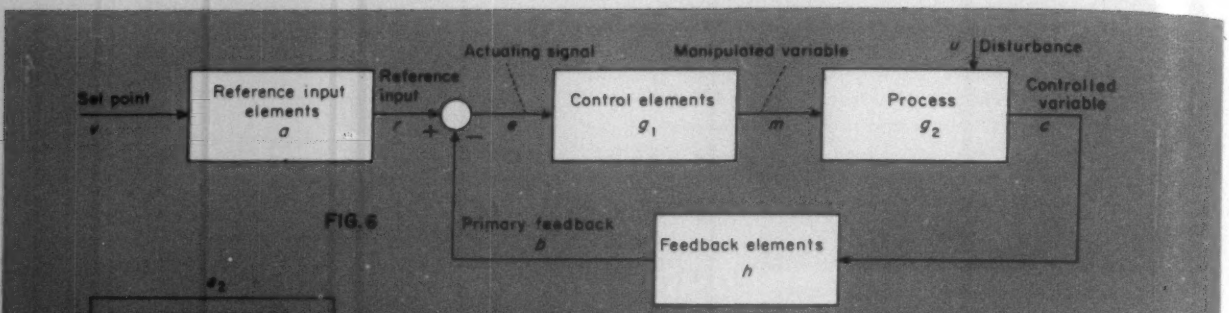
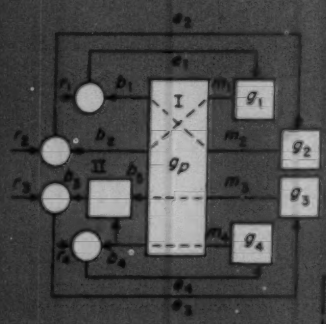
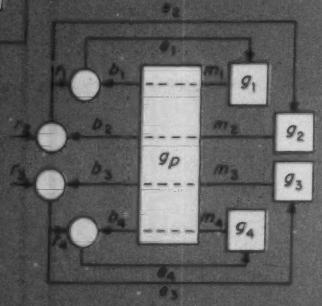


FIG. 6



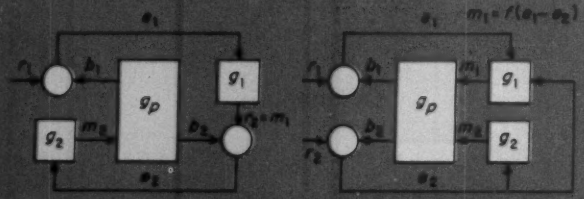
COMBINATION AUTOMATIC CONTROLLER FEEDBACK COUPLING

I. Within process
II. From elements



INDEPENDENT CONTROLLERS

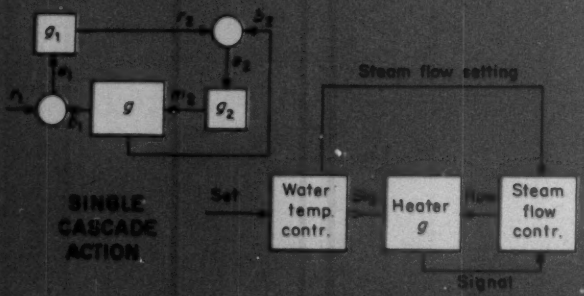
Coupling only secondary feedback disturbances. g_p combines process and feedback elements



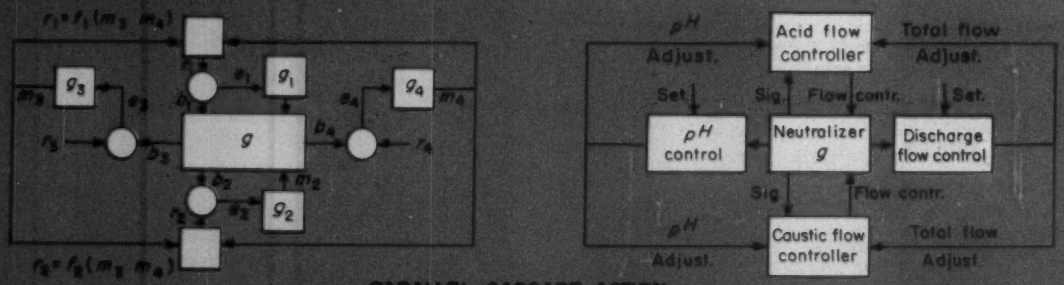
Reference input coupling

Control element coupling

COMBINATION AUTOMATIC CONTROLLER



SINGLE CASCADE ACTION



PARALLEL CASCADE ACTION

of a feedback control system is shown in *Fig.* 5.

If required the diagram may be expanded as shown in Fig. 6. In the explanation of automatic control combinations which follows, this nomenclature will be generally used. In some cases a single letter will be used to designate several paths through the process. More detailed analysis requires a different letter for the dynamic characteristics of each path.

AUTOMATIC CONTROL COMBINATIONS

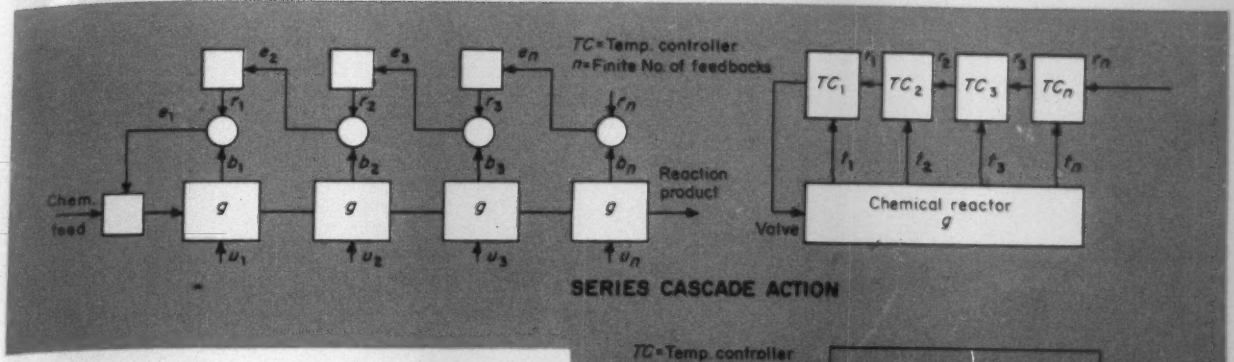
901. A COMBINATION AUTOMATIC CONTROLLER is more than one closed loop connected in combination, the loops being coupled through primary feedback or any of the controller elements.

The distinction should be carefully made between a plurality of independent automatic controllers with no coupling except for secondary feedback disturbances and a combination automatic controller with definite coupling between two or more loops.

902. COUPLING is that connecting means through which signals or actions directly related to two or more closed-loop automatic controllers are combined to achieve a control function beyond the capabilities of independent automatic controllers.

Coupling may occur as (a) feedback coupling (b) reference input coupling (c) control element coupling.

903. A COUPLED REFERENCE INPUT OR CASCADE COMBINATION is one in which the control output, or the actuating feedback signal from one automatic controller is used to regulate or readjust the set-point or modify the reference input signal of one or more other automatic controllers.



SERIES CASCADE ACTION

903a. SINGLE CASCADE ACTION is the regulation of the set-point on one automatic controller by the action of another automatic controller.

Time program control does not constitute a closed loop unless time is affected by feedback.

903b. PARALLEL CASCADE ACTION is the regulation of the set-points of two or more automatic controllers by the action of another automatic controller.

903c. SERIES CASCADE ACTION is the regulation of each of a number of automatic controllers by the action of the preceding automatic controller in the series.

904. A COUPLED FEEDBACK ELEMENT COMBINATION is one in which the primary feedback to an automatic controller is a function of the primary feedback actuating signal or control output from one or more other automatic controllers as well as from its own measuring means.

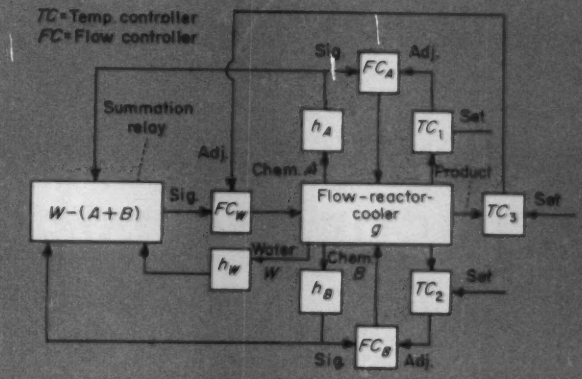
904a. SUMMATION ACTION is the coupling of one automatic controller primary feedback with another or with other automatic controller actuating signals to function as the algebraic sum of the combination.

Special cases are Cutback, Limiting, Overriding and certain types of Proportioning Action.

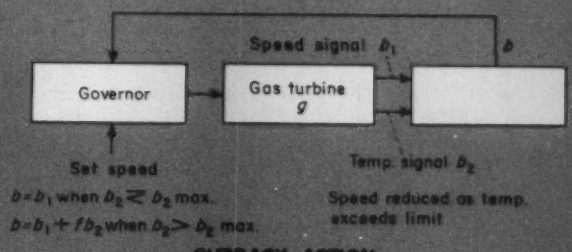
904b. CALCULATING ACTION is the coupling of primary feedbacks with one another and/or any other actuating signal (s) to follow any computable function of the combination.

Typical cases are Ratio Action, Multiplication Action.

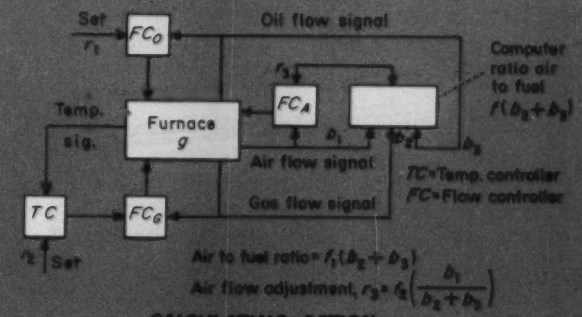
905. A COUPLED CONTROL ELEMENT COMBINATION is one in which two or more feedback or actuating signals or control element actions are combined to operate one controlling means.



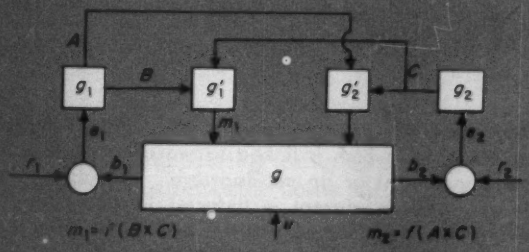
SUMMATION ACTION

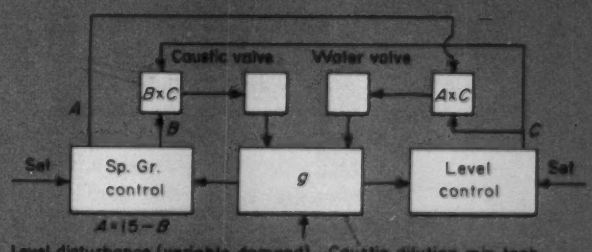


CUTBACK ACTION

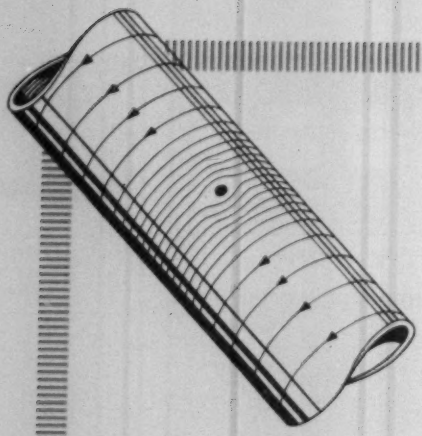


CALCULATING ACTION



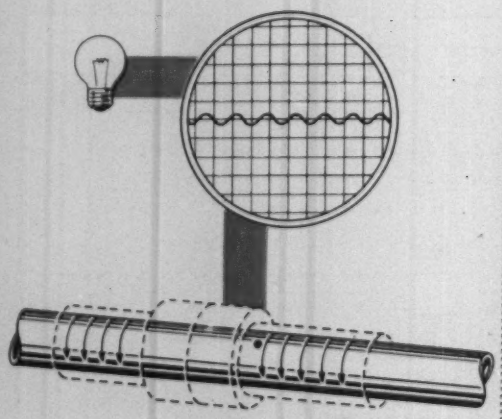


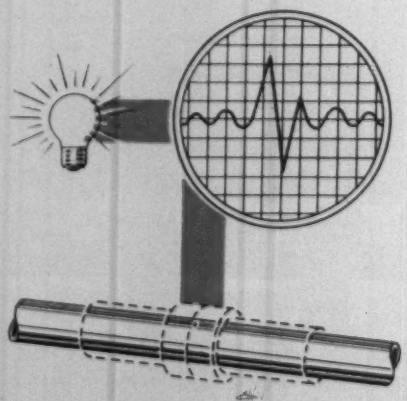
COUPLED CONTROL ELEMENT COMBINATIONS



INDUCTION INSTRUMENT

INSPECTS WELDED TUBING





INSPECTION METHODS requiring destructive testing or slow, sample testing are seldom in tune with requirements of continuous process production. This was the problem when tubular steel products were tested in either or both of two ways—destructively in which test sections are crushed, expanded, flanged, flattened, and bent to reveal any large or continuous defects; and nondestructively in which water, air or other gases are pumped into a section of tubing under high pressure to detect smaller defects. A novel method, known as Farrowtest, eliminates these cumbersome procedures.

Developed by Cecil Farrow of Republic Steel Corp. this arrangement is a means for fast electrical nondestructive testing. Coupled with the production advantages of tubular products electrically welded from flat rolled steel, this inspection system insures meeting rigid specifications for boiler tubes and steel tubing for aircraft at high output.

Holes and flaws with diameters as small as a few thousandths of an inch divert circumferential current induced by an induction coil. Detector coils sense this longitudinal component of flow and the signal created can stop passage through the machine of the tubing being tested, sound an alarm, or place an identifying mark on the tubing to locate the flaw.

Tubing containing a tiny hole or other defect is passed through a coil which is linked to warning controls such as a signal light or an oscillograph. As tubing enters the coil, electric current is induced in the tubing circumference. Waves of current swerve to either side of a defect and then resume their path. This sideward movement, however slight, is sensed by small detector coils mounted on the large induction coil and warning signals are activated

A SPECIAL STUDY

AUTOMATION

INDUSTRY PLANS FOR MORE AUTOMATIC OPERATION

By ROGER W. BOLZ
Editor

GROWING GRADUALLY throughout all industry is an awareness that practical automation holds the answer to many of today's problems in producing a marketable product—quantity, quality, and costwise.

In some cases it becomes imperative to produce at phenomenal levels to satisfy consumers at reasonable rates. No amount of hand labor, however well disposed, could produce acceptable results. Actually, to provide a saleable product offering uniform service to all purchasers precludes any large percentage of hand manufacture. All too many examples of complete failure of random-quality products can be cited. And costs—a factor always to be considered when the ever increasing proportions of taxes, handling and wages are considered—must be hammered to the lowest possible level if the basic aim of putting a vast array of products within the reach of everyone is to be accomplished. Considering gains already made over a wide area, automation holds an important key to the future of industry—if carefully and wisely administered.

Since its inception, AUTOMATION has endeavored to portray some of the tremendous achievements in the field of automation in industry. This tiny glimpse into the present-day panorama of the slowly unfolding and broadening automation engineering concept offers some small idea as to the real possibilities.

Because of its broad horizontal nature, automation demands greatly increased co-ordination of all phases of engineering and management. Unlike conventional procedures, automation cannot be handled on a piecemeal offhand basis. For success, all phases starting with top management planning and including accounting, market research, product design, production, plant engineering, sales and distribution must be co-ordinated properly for success. Factual "dollars and cents" information is required and from this standpoint it is often necessary to obtain and supply the engineering group with such information from many sources. In some cases, outmoded methods of accounting must be revised and more realistic systems developed to provide the needed data.

Once the full perspective and potential of automation is apparent from thorough study by management and engineering, its application in proper degree can result in real advance. The necessary engineering skill and knowledge can be obtained or developed and the basic elements for automation

IN 1955
921 PLANTS OF THE 2980 REPORTING
EXPECT TO SPEND

$347,677,000

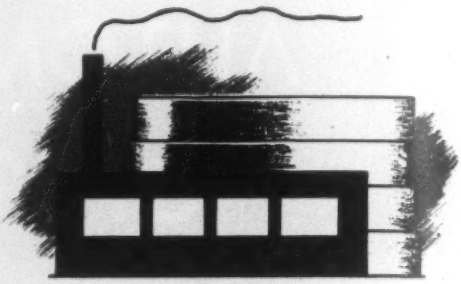
for

AUTOMATIC INSTALLATIONS

Average investment per plant proved to be strikingly similar

$19,924,000

will be spent by
SMALL-LOT PRODUCTION
PLANTS



Averaging
$255,000 per plant

are available. The question today is not will there be automation but, how much and how soon for any particular set of circumstances?

The question invariably arises as to just how extensively automation is now being used. In answer, a survey of industries shows the application of these broad principles to be far more extensive than is usually realized. Many items of necessity on the market today are available in quantity and quality at modest cost only because of gradually evolving automation.

Such homely products as light bulbs, foodstuffs, can openers and toothpicks reach the modern market only by virtue of high-level automation. No one would think of relinquishing their availability or decrying the methods by which they are made available. The important factor is to learn from these widespread long-term developments how further advance can be achieved in other areas of industry.

▶ Industry-Wide Survey

To learn just how extensive the trend toward greater automation actually is and in general the directions in which it is moving, AUTOMATION has conducted an industry-wide survey. Results of this survey are shown in the accompanying charts. In returns from 2980 plants some 920 reported expected investment figures which in aggregate totaled close to half a billion dollars for 1955. For industry as a whole this indicates a strong positive movement of tremendous proportions worthy of real consideration.

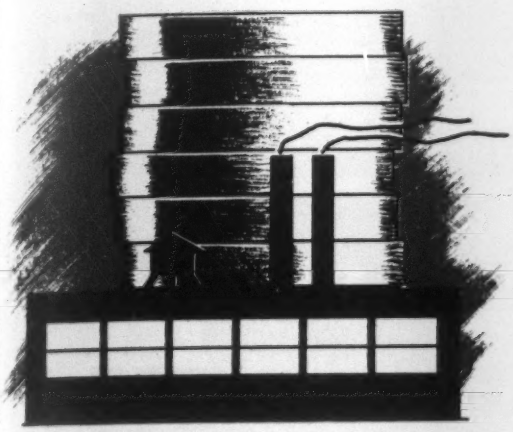
In keeping with the general practical requirements of industry, no particular phase of automation in this survey of industry has shown up as an unusual or outstanding trend. The plans for automation in general indicate a strong increased usage of all conventionally available equipment. Almost every industry known today represented in this survey indicated either some use of automation or plans in process for early development. Inasmuch as the time of development for any full-blown automation installation is substantial, and often has required years, there also emerges from this survey an indication of much future progress. The end results are still to be seen as the canvas of growing automation is slowly and laboriously painted.

In overall perspective, there emerges a dynamic picture of tremendous industrial development, tremendous achievement, and undisputed advance in working conditions, living standards and personal well being of all Americans.

$104,290,000

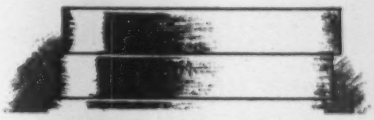
will be spent by

MEDIUM-LOT PRODUCTION PLANTS



Averaging

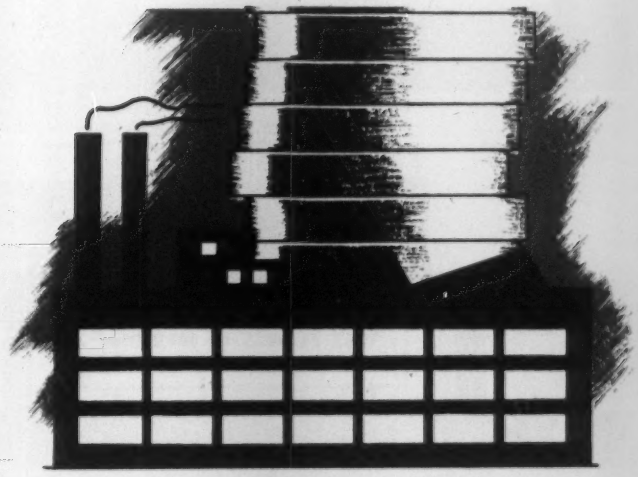
$287,000 per plant



$222,438,000

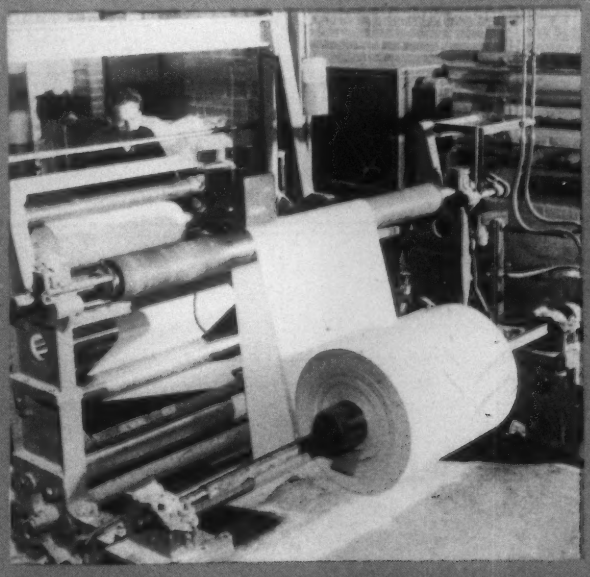
will be spent by

LARGE-LOT PRODUCTION PLANTS

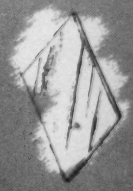


Averaging

$474,000 per plant



High-speed Cameron bread wrapper waxed paper slitter and rewinder is automatically controlled by a Westinghouse SC-2 electronic slitter regulator.



GLASS MANUFACTURE

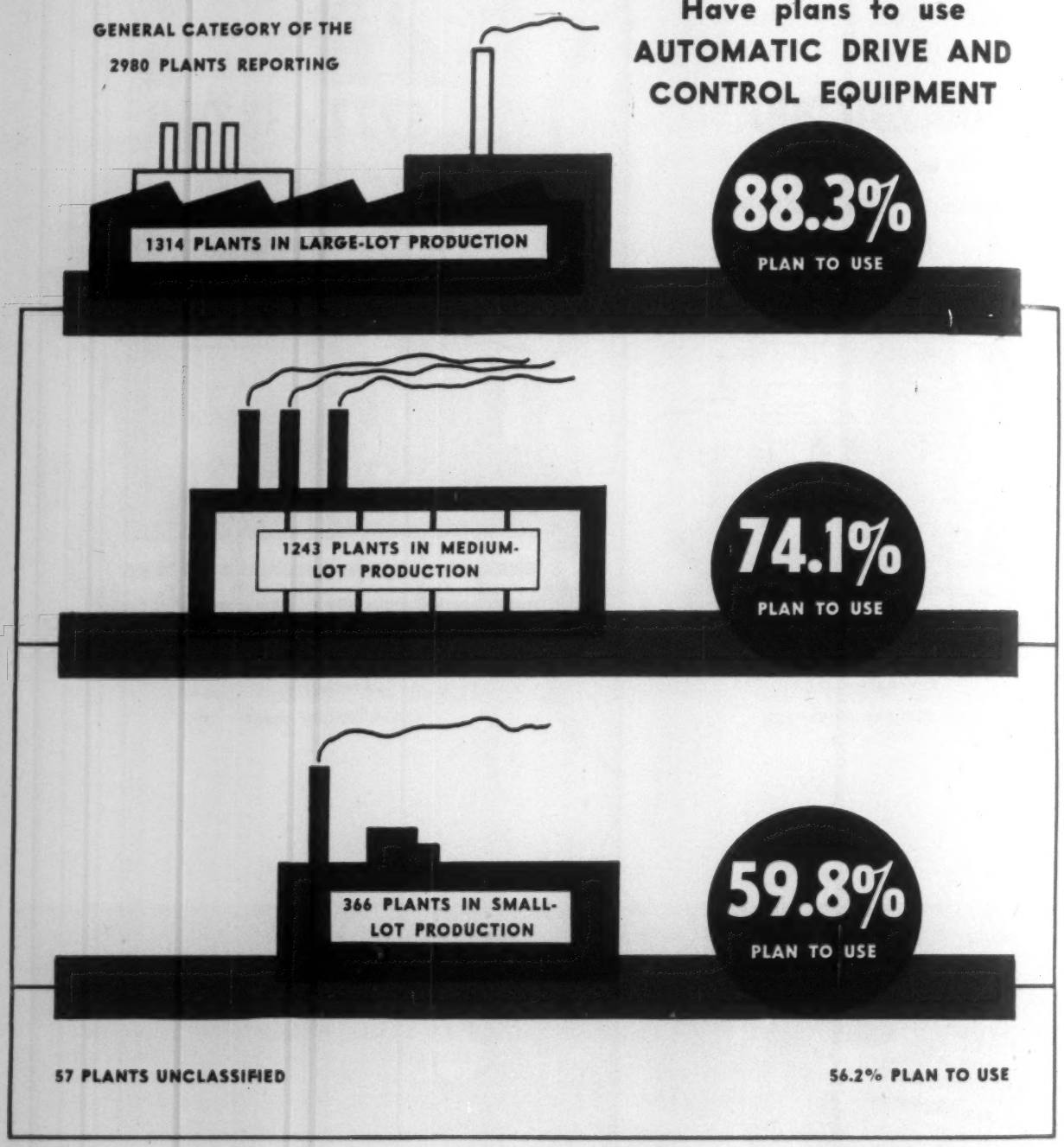
In a single large plant 120,000,000 kwhr are consumed in one year in producing plate glass. Electric power applied through automatically controlled processes enables meeting demand for volume production.

CHEMICALS

One chlorine and caustic soda plant produces its finished products from the contents of a mammoth salt dome by means of 85,632 hp in electrical equipment.

COAL RECOVERY

A six million dollar plant near Lancaster, Pa. recovers 100 tons of dry river coal per hour from river bed silt with 4200 hp in motor drive equipment.



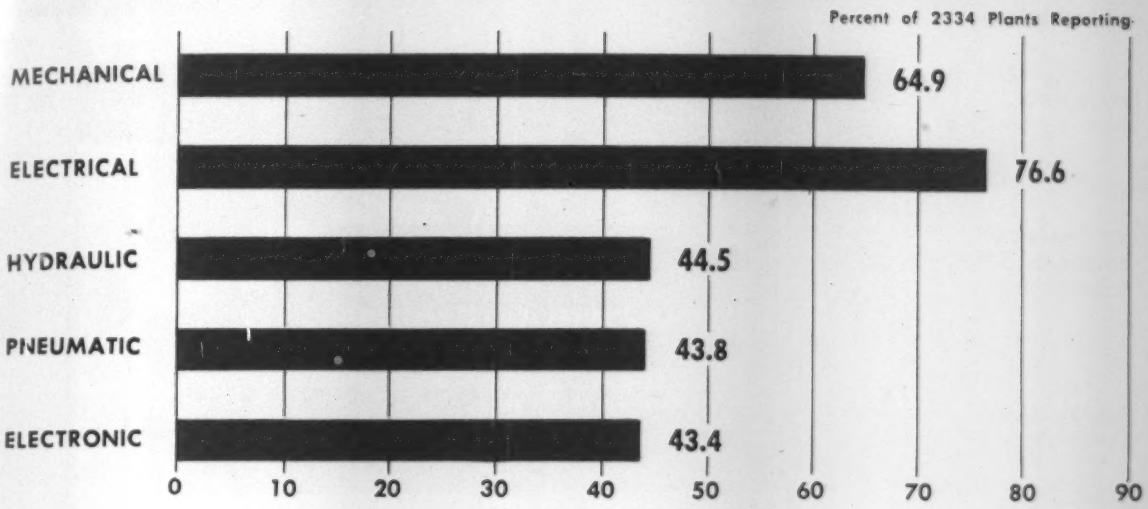
STEEL FINISHING

Irvin works of U. S. Steel Corp. near Pittsburgh, Pa. has an annual capacity of 1,406,700 net tons of finished sheet, galvanized and tin plate products. To make possible this finishing production only, some 40,000 hp in electrical drive and control equipment is necessary.

PIPE PRODUCTION

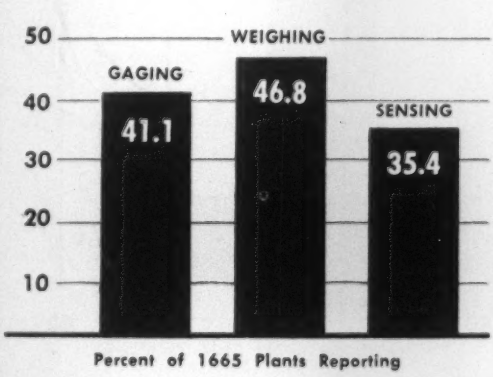
The "continuous" seamless pipe mill at Lorain, Ohio requires 60,349 hp in electric drive equipment. Some 345,000 ft of rigid conduit was required for the installation.

TYPES OF AUTOMATIC DRIVE AND CONTROL EQUIPMENT PLANNED

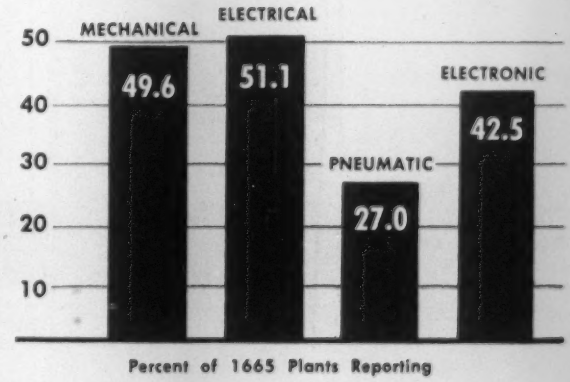


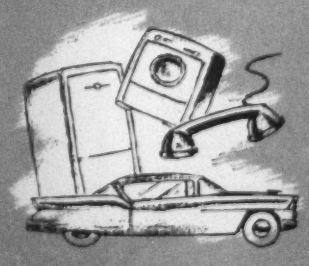
AUTOMATIC GAGING, WEIGHING AND SENSING DEVICES

EQUIPMENT PLANNED



TYPES TO BE USED

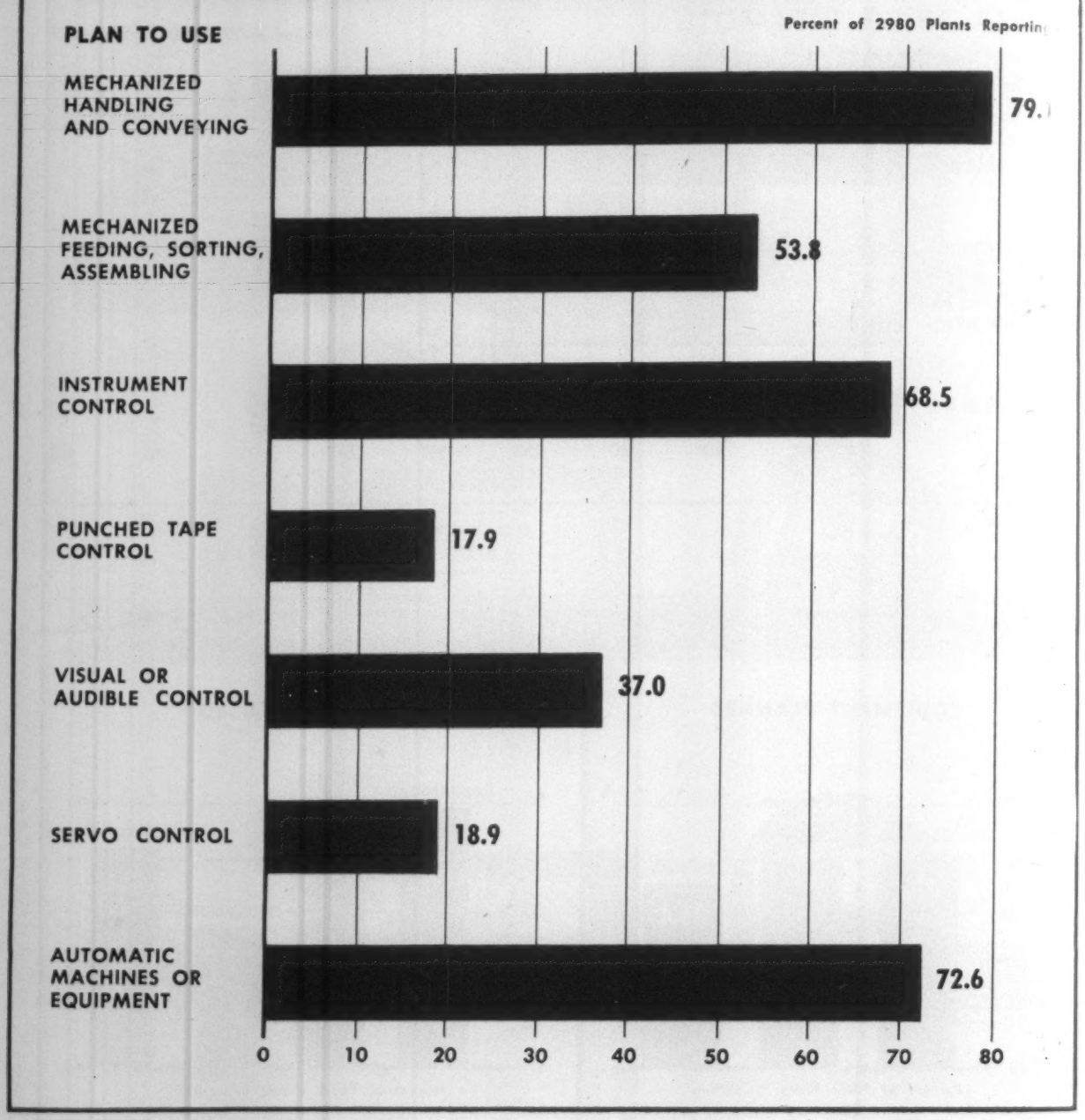


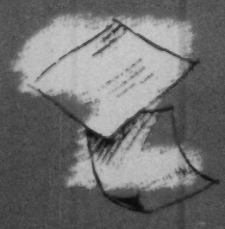


GOODS AND SERVICES

Value of goods and services produced in the U. S. in 1965 will probably be 50 per cent greater than at present. Dr. Gordon W. McKinley, chief economist of the Prudential Life Insurance Co. predicts a gross national product in 1965 of $540 billions compared to $365 billions now, an increase of 37 million persons over today's level, a labor force of 77 million, and total personal income of $420 billions representing a 25 per cent increase in personal income per worker.

OTHER AUTOMATION EQUIPMENT



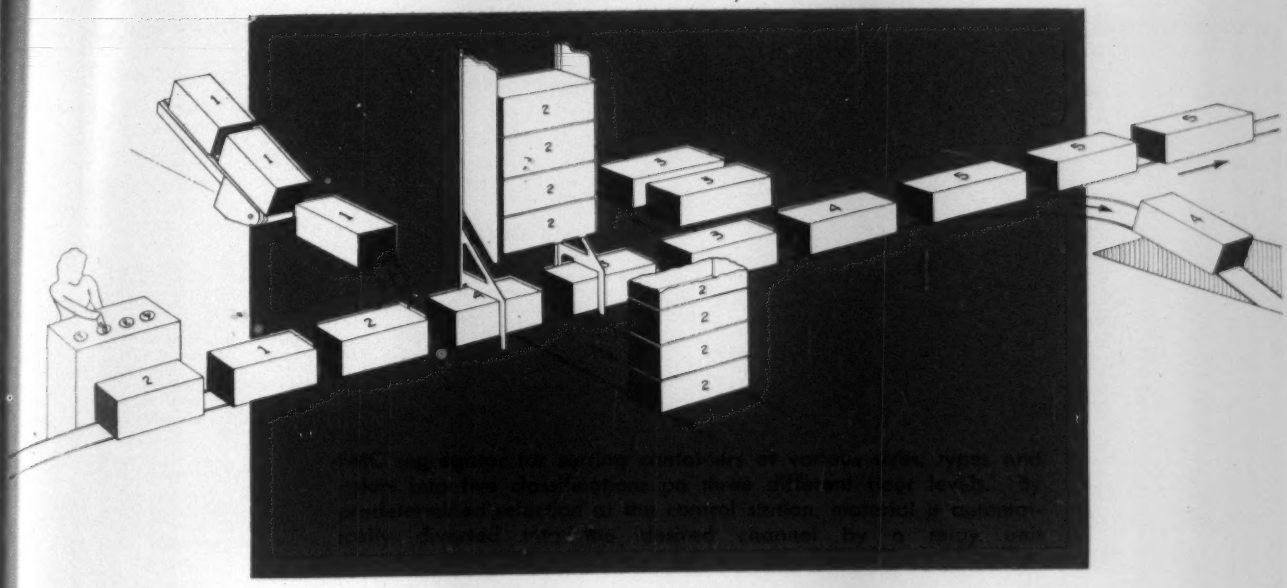


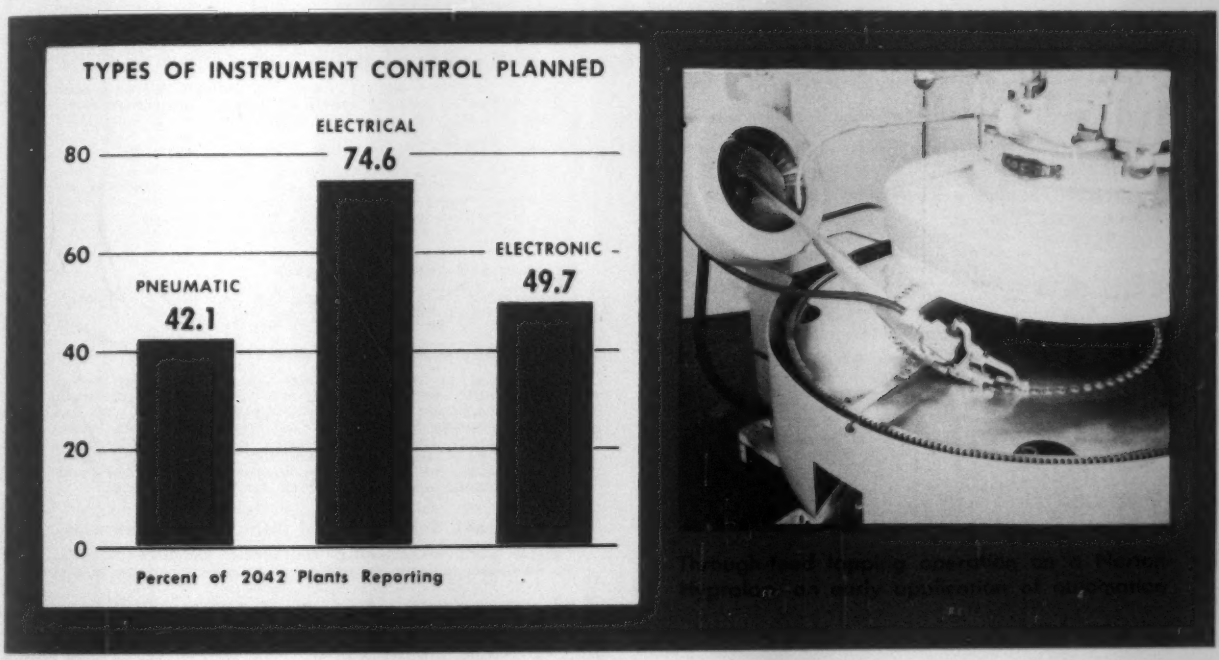
PAPER AND PRINTING

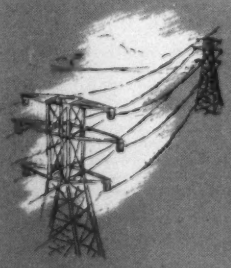
Increased use of paper will raise the electrical consumption of the paper industry 100 per cent in the next ten years owing to increasing automation. Power consumption in the printing industry will rise 25 per cent.

AUTO PARTS

An idea of the vast job done by automatic assembly can be gained from the fact that one Chevrolet contains 19 Delco-Remy built units with a total of 1376 individual parts. All are assembled automatically at high speed to make possible low unit costs and uniform high quality.







ELECTRIC POWER

With increasing use of automation or continuous automatic production by industry, 90 per cent of all horsepower used by industrial workers in 1965 will be electric.

PETROLEUM REFINING

At the Wrenshall Refinery of International Refineries Inc. is one of the first single-unit construction continuous-flow, all-automatic design installations in service. There are some 150 employees required even though only three engineers are needed at the master control panel.

General Survey Comments

(Plants and equipment which respondents expect to be automated in next five years)

Primary Metals

Automatic lading equipment—tube mills and tube fabricating equipment—sequence control filling of blast furnaces—rod drawing of sizes ⅝ to 1 inch—furnaces—rolling mill equipment—punch presses—pipe casting and handling equipment—some foundry equipment—semi-automatic pipe manufacture—sand mulling machines—moisture and mix controls—complete foundries—foundry sand preparation—sand handling, mold handling, shake-out and casting handling—core making—shell molding—entire carbon plant—aluminum mills—shears—wire drawing, pickling and annealing operations—conveying equipment—powerhouse equipment.

Fabricated Metal Products (except ordnance, machinery, and transportation equipment)

Equipment for manufacture of hinges—roll-out seats—aircraft fuel pumps—windows and wall panels—stampings and sheared parts—eye machines for springs—feeds for tapering rolls—special spring coiling equipment—welded side seam steel pail and drum manufacturing—scuff plate embossing—buffing operations—fan rotor and housing parts.

Machinery (except electrical)

Machine tools—punch presses—drilling and tapping machines—machinery for chip removal—bellows fabricating and charging equipment—sheet metal press lines—duplicating lathes—seamless and welded tube mills—enameling and baking machines—screw machines—food and dairy processing equipment—electronic equipment fabrication machines—broaching machines—boring mills—wire rolling equipment—machines for the manufacture of small diameter sheaves and hubs.

Making of gravity rollers for conveyors—progressive die punch operations—food processing machinery for freezing, carton filling and closing—can handling—paper processing machinery—coal preparation plant machinery—fabricated wood door machinery—steel track forming—tractor track shoe, track link, track roller, and pin and bushing lines—cylinder block and head lines—electronic chassis assembly machines—wire production.

Accounting and information storage equipment—equipment for the printing trade—all types of loading and unloading devices—automatic assembly equipment for electrical or small mechanical assemblies.

Electrical Machinery, Equipment and Supplies

Transformer and coil manufacture—glass metallizing—meter testing equipment—manufacture of electronic components—production of tubular and ceramic capacitors—mount assembly operations—some facilities in magnetic recording components — selenium rectifier production — transistor production.

Transportation Equipment

Sheet metal components manufacture—testing equipment—continuous metal processing and finishing—press operations interconnected with processing, assembly, testing and product finishing—valve manufacture—production equipment for fire detection cable—screw and stud driving—rim production line—metal and trim fabrication—automatic transmission production—hydraulic hatch covers—lifeboat releases—side shell doors.

Mining

Iron ore beneficiation equipment.

Coal—additional equipment and pumping controls—more automatic handling—continuous "miners" in deep mining—processing—recovery.

Ordnance

Machine tools such as milling machines, engine lathes and gear shapers—dimensional control—heat treating.

Food and Kindred Products

Sugar boiling—centrifuging of raw sugars—material handling facilities—packing equipment—practically all distilling operations—sliced bacon handling—bread depanning—new method bread dough ferment—fully automatic production of rolls in bakeries.

Tobacco Manufacture

Machines for breaking up hogsheads of tobacco and depositing small pieces on conveyor—related feed and conveyor equipment.

Textile Mill Products

Automatic control of calender nip from existing gage recorder—rewinding machines—equipment for worsted combing and drawing.

Lumber and Wood Products (except furniture)

Window manufacture—cross milling, lineal milling, routing, drilling—doors.

Furniture and Fixtures

Punch presses—cutting and sewing—wire and wrinkle control—cover cutting, sewing, frame machining, finishing—paint application—press brake forming.

Paper and Allied Products

Production handling—paper cup machines—paper cups and envelope machines—control of stock plus stock preparation equipment—automatic tension control—automatic caliper control—humidifiers—feeding equipment on printing and cutting presses—digesters—paper mill equipment—pulp refining—partial operation of corrugating machines—basis weight on paper machines will be most important development—expanded use of "inline" carton making equipment—improvements in paper converting equipment—power plant—set-up of printer-slotters and other box making and fabricating machines—warp control on corrugating machines and automatic sheet length indicators.

Printing, Publishing and Allied Industries

Presses—cutters—material handling—bindery—further extension of automatic rewind and speed control on press and collation equipment—mailing room equipment—some type production—automatic roll changing devices—assembly of forms—finishing room processes.

Chemicals and Allied Products

Nitric and sulphuric acid plants—specialized equipment for explosives—drum conveying—bulk handling equipment—treaters—presses—conveying equipment—raw materials proportioning equipment—chemical processing equipment—strength control of solution in HNO_3 absorption towers—roll sulphur pouring—rock salt bagging facilities—equipment related to reaction, settling, washing, filtering—temperature controls and counters.

Products of Petroleum and Coal

Drum facilities—control rooms of future units—greater automation in refining generally—process instrumentation.

Rubber Products

Stacking of sheet rubber blanks—tires—assembly of footwear parts—compounding of raw materials—molding operations—curing of tires and more automation in their building—calender let-offs and wind-ups—partial automation of heavy basic rubber mixing equipment.

Leather and Leather Products

Automatic feed machines on basic operations—tanning—processing of hides.

Stone, Clay and Glass Products

Raw feed to raw preliminary cement grinding mills—rotary kiln operation—finish mill—pack house—automatic brass production facilities for fittings—bath tub, sink and lavatory production as well as small parts lines—sewer pipe forming and handling—speed testing wheels—pressing wheels—glass block and foamglass manufacturing facilities—coating or crushing machines—batch mixing—forming machines—material handling for bulk materials.

Professional, Scientific, and Controlling Instruments

Meter parts manufacture—mechanized assembly—handling—lens manufacture—stamping—glass processing—machining.

Miscellaneous Manufacturing Industries

Brush making—automatic knife cutters—silk screen printing—solvent recovery collection and distillation.

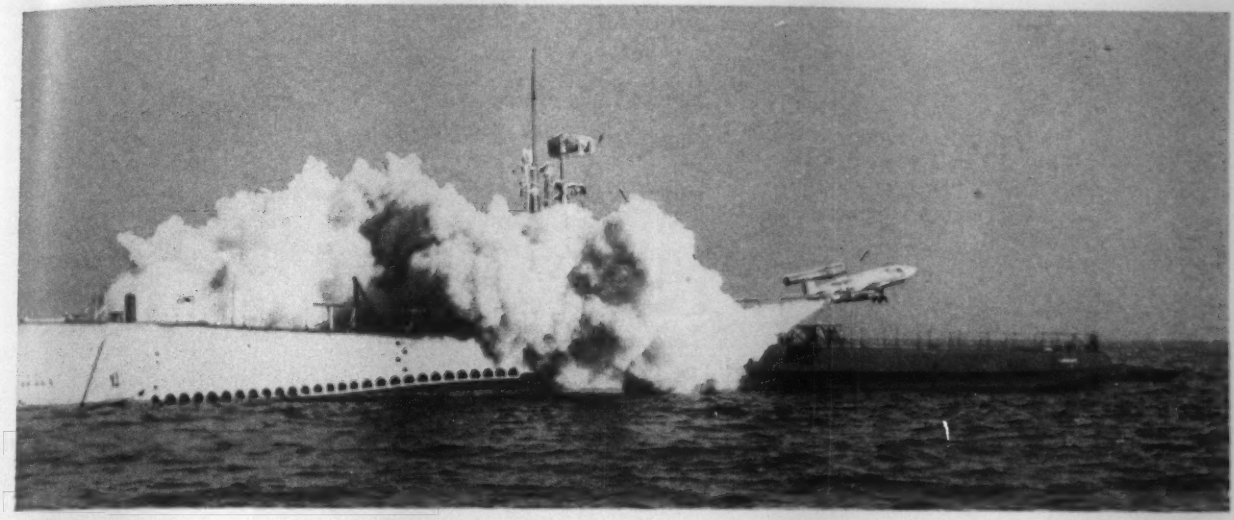
Pipe Line Transportation—Retail Establishments—Banking—Insurance

Further expansion of pumping stations—data processing—casing of paper milk bottles after filling—bagging and sealing ice cream cartons—posting to depositors accounts—routine computations.

Engineering and Architectural Services

Automatic production of aluminum extruded louvres—more use of electronic control equipment and hydraulic equipment—electronic components—electro plating—coil winding—sugar mill machinery—heavy labor saving machinery—precision machines—plant controls—mechanical metal working presses—forging presses—hydraulic presses—engine parts—transistor manufacture—single-purpose machine tools—textile and jewelry production equipment—warehouses—machine shop—automatic handling—numerous chemical processes—pinion gear manufacture—pharmaceutical production — ordnance plants — sanitary engineering — food processing "from plant or tree to package"—pulp and paper mills.

Copyright 1955 AUTOMATION—Penton Building, Cleveland 13, Ohio



Successful systems engineering requires effective organization at the project level

MANAGEMENT OF SYSTEMS ENGINEERING

THE PROJECT TEAM

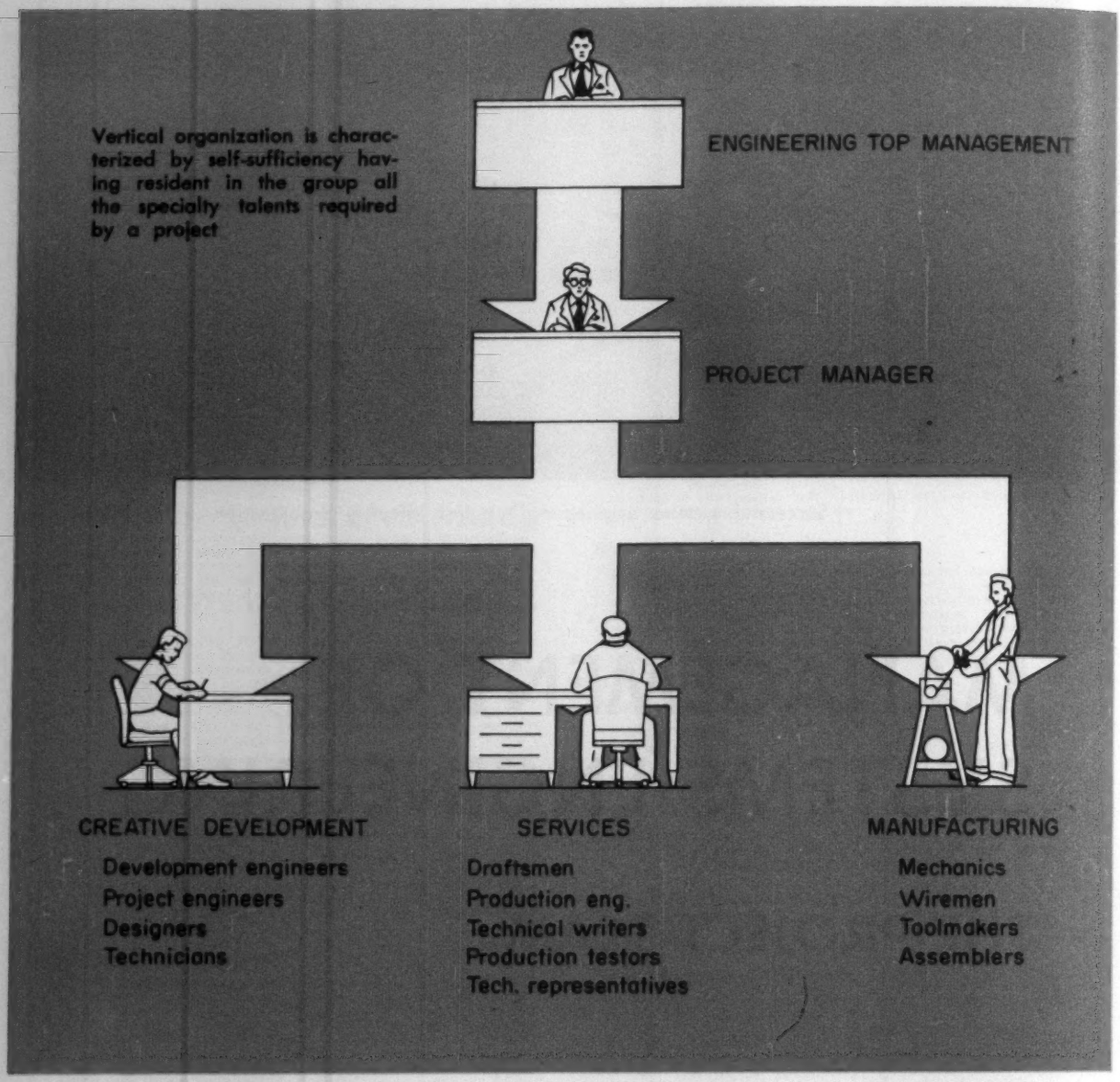
Part 2

By E. D. GITTENS
Chief Engineer, Arma Div.
American Bosch Arma Corp.
Garden City, L.I., N.Y

Judgment of organizational structures is refined by a studied appraisal of the best alternatives. Advantages and disadvantages of both vertical and committee organization of project teams engaged in engineering solutions to complex problems are compared. This article concludes in favor of the committee whose members are drawn from departments of functional specialty

INCREASED DEMANDS on engineering staffs involved in guided missiles, supersonic aircraft, and modern industrial process controls result in an emphasis on the technical specialist and a means for integrating his concentrated skills into an effective organization. Part one of this series discussed the new challenge to engineering management that has been created by the growing requirement for "Systems Engineering" brought about by the increasing complexities of many of today's engineering problems.

It was shown that one approach to a management technique for a company engaged in systems work was to organize the subdivisions of the engineering organization along functional lines. Each type of specialized activity found in systems engineering is recognized as a department and is formally established as a working group, with its own supervision and staff of specialists. This provides a means of concentrating like skills in a manner



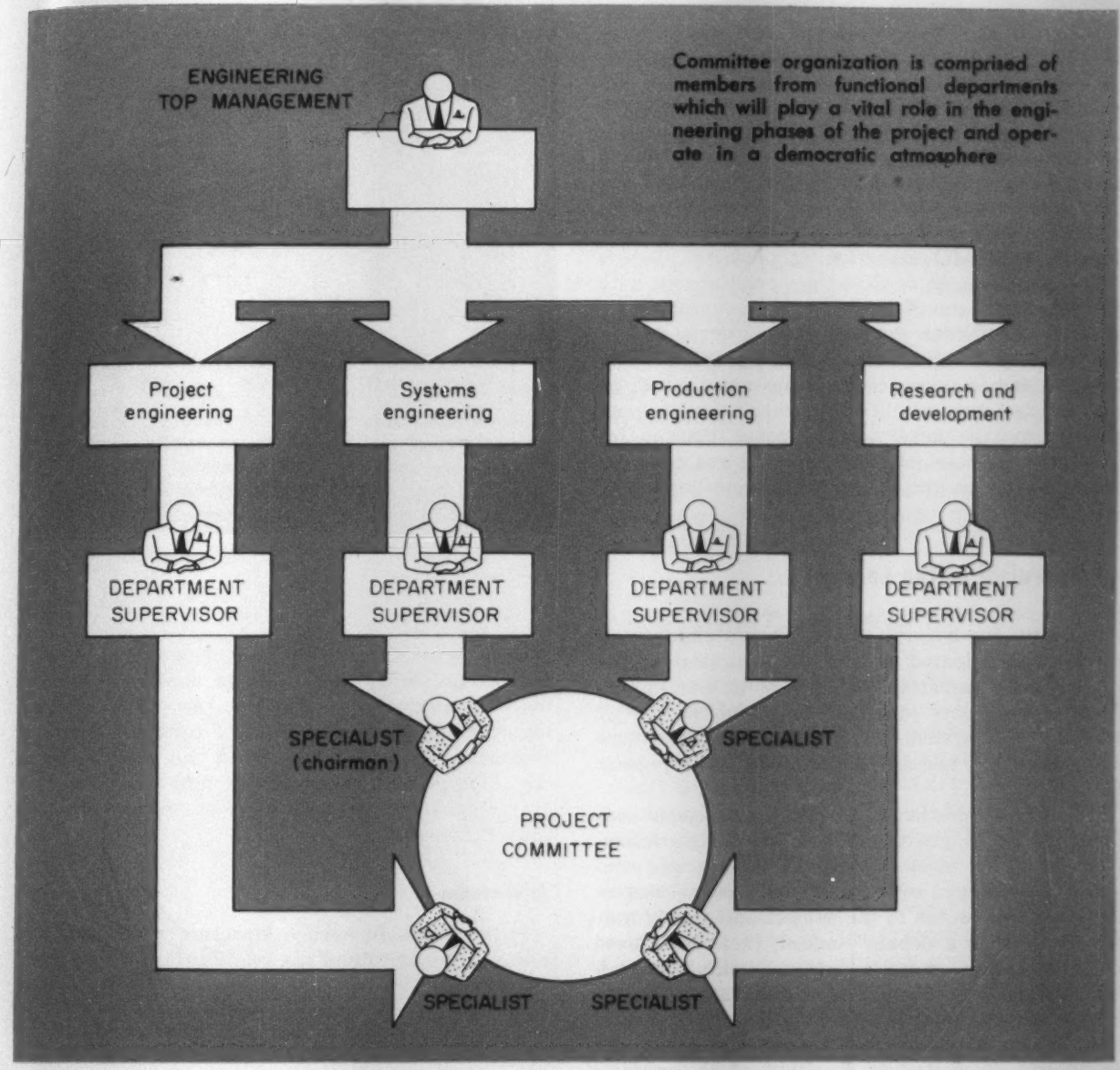
which permits the department to become a powerful storehouse in which these skills may develop and expand their own specialty and also to serve as a source of strength to be tapped for project application.

It was further developed in this earlier article that a means of rallying these specialties around a particular project was through the medium of a "Project Team." This is the concept of project management that has been in use in the Arma Div. of the American Bosch Arma Corp. for many years and has permitted this organization to handle a great variety of complex automatic control systems involving the application of large numbers of technical personnel having a wide range of specialized talents.

This engineering staff totals over 1000 and its products range over the field of gyroscopics, electronics, automatic computers, and fire control systems used by the Army, Navy, and Air Force, and special systems used by the Atomic Energy Commission. It was against this background and in this atmosphere that the project team concept was evolved as a method of managing the requirements of systems engineering.

What is a Project Team? It is a group of engineers organized to be responsible for the administration and technical execution of an assigned project.

How is a Project Team Formed? The need for a project team is created by an assignment of a new project or task to one of the specialized engineering departments as dictated by the type of project involved. Such an assignment is made by the chief engineer and places project cognizance and responsibility on the supervisor of the assigned department. In order to carry out such an assignment, the supervisor must arrange for a working level group to be assigned. Hence, the need for a project team.



The cognizant supervisor determines from the nature of the project the types of engineering activities which will be necessary in its prosecution and arranges with the supervisors of the appropriate departments for the appointment of team members—the member of his own department usually being appointed project coordinator.

Responsibility and Authority

By virtue of its varied composition, the team, through its respective members, draws on the diverse talents and specialized knowledge of their individual departments during each phase of the project development. During the evolution of the project, each member has an opportunity to bring his own specialized talent strongly into play, whether it be mathematics, electronics, hydraulics, production engineering, or others. Each team member, however, takes an active part in each type of specialized technical activity to the extent of his ability, regardless of his department affiliation. This has the double advantage of providing the maximum ideas in the solution of problems, and serves as a multiple check of all work going through the project. *Group effort* is applied to *every* phase of project activity.

The responsibility for the successful conclusion of an assigned project rests equally on each member of the team. The willingness of each member to recognize that the success or failure of his team project is his own personal responsibility is the obvious ingredient of a successful team. Such an attitude negates the possibility of "buck-passing" between members and promotes an *active interest* on the part of all members in the individual work done by each member within that member's specialty.

The project team has complete authority over the

project administration and technical development subject to periodic review of their respective supervisors. This can be a serious source of trouble if improperly delineated or misunderstood. Team members must realize that their respective supervisors have a responsibility to higher management for the successful execution of projects. Supervisors must recognize that their relationship with the team consists of guidance and counsel. A restrictive attitude on the part of a supervisor nullifies the responsibility assigned to the team. Conversely, each member of the team must recognize the broader responsibility for project management resident in the supervisor. Proper respect for each other's duties, through training and clear-cut policy, is the answer to a harmonious relationship.

Gyroscopics, electronics, automatic computers, and fire control systems used by the Army, Navy, and Air Force are handled by the systems engineering approach

▶Appraisal of the Concept

Recently the supervisors of Arma's engineering division participated in a group appraisal of the project team operation with a view to determining from a completely objective viewpoint whether it was the best system for handling their problems and whether it should be continued in its present form.

The whole question of project management was investigated in great detail down to the fundamentals of the matter. The discussions and considerations ranged over all of the classical organizational approaches to the subject and finally narrowed down to a debate—indeed, there were even debating teams—over the vertical method of project management versus "semi-horizontal", or the committee type of structure.

It should be clearly understood that the entire study was conducted in the light of the particular management requirements prevailing at Arma. This involved the problem of establishing a management means which would be best suited to the effective prosecution of fifty or more complex projects carried on simultaneously. Further, the organizational plan being sought had to be sufficiently flexible at all times to permit the ready acceptance of highly variable assignments. Obviously, this situation was a controlling factor in any deliberations on organizational possibilities.

Since this is not a unique management problem, however, some of the highlights and considerations which evolved from this study are worthy of note and are set forth in the following discussion.

▶Vertical Organization

The classical vertical arrangement for project management is characterized by an inherent self-sufficiency of operation. It has within its structure all the necessary specialized skills to provide complete engineering capabilities and it also has the ability to carry on its own laboratory investigations, preparation of drawings, and model or prototype manufacture. Further, one of its salient features lies in the alignment of responsibility and authority. It is autonomous in this respect, with the total project responsibility and the attendant authority vested in the head of the group—the project manager.

Advantages

It is simple. In such a structure every member can easily understand his relationships and duties. Further, as viewed from without, its identification with a project is complete and communications to the project are sharply focused by the project manager.

Responsibility and authority are clear-cut. Total project responsibility and authority are clearly vested in the project manager. By delegation and assignment to lower levels, each member of the group has a clear understanding of his own job.

It has a stable composition as a working group. During the life of a project all group members are continuously associated with it and follow through to its completion.

It is fast-acting. Being closely knit and under one-man direction, it can handle jobs very rapidly and effectively.

Communications are good. Obviously, the line of communication is simple and direct. Information can flow up and down the line easily.

Discipline is easily maintained. The authority vested in the Project Manager provides a "strong hand" for handling personnel problems and giving orders.

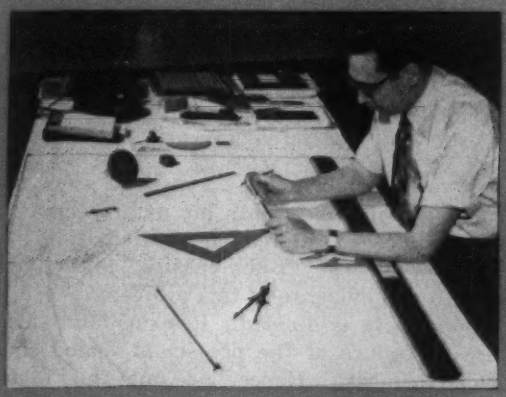
Disadvantages

The organization is rigid and inflexible. It can become too specialized to adapt itself to rapid

changes should its assignments be markedly changed in character.

It is an autocratic system. Being an autocratic system, it may be operated on an arbitrary, opinionated, and dictatorial basis. Further, project managers may carry out orders independently and often in accordance with their own whims and desires. The morale of group members in this type organization is often lowered by the lack of freedom of thought and action.

Lack of cross-checking. The advantages of cross-checking between groups on similar projects may be lost due to the autonomous structure. In addition, if there are a number of other projects going on simultaneously within the company, it often happens that the same problem is being solved by each group without benefit of mutual consideration. Worse—it often happens that a solution to a particular problem exists in one group while another unknowingly continues to struggle with it.



Each individual is naturally broadened as a professional man and tends to find his work more interesting and challenging

Undue demand for extra-high calibre personnel. Since all the specialty talents required by a project must be resident in the group—to the exclusion of their use on any other project—the quality of the resultant product is too often a direct function of the quality of the individuals. This results in the need for extra-high calibre personnel in every important post on every project.

Organization is sensitive to individuals. The key men tend to become overloaded and inefficient and the organization can become internally strained by its reliance on the individual. The loss of one or two capable men can seriously cripple the entire project.

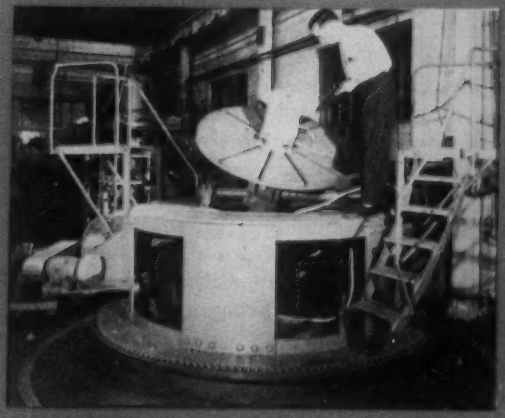
Effectiveness tends to be limited. This arrangement works well on relatively small projects or in an organization dealing with only a few projects. However, it tends to become cumbersome in the aggregate if there are a large number of complex projects. Further, if any one project requires many varieties of skills and a large staff, the project manager can easily become a serious bottleneck.

Makes inefficient use of personnel and facilities. By virtue of its self-sufficiency, facilities have to be duplicated in each project. In addition, specialized personnel assigned to the project are not available—whether fully occupied or not—to exert their specialties on other projects. Both situations tend to reduce the efficiency of the total company organization.

Open to "empire building". Due to the reluctance of project managers to break up their organization as a project diminishes in workload, it becomes difficult to reassign personnel to other areas of activity as needed.

▶ Committee Organization

The committee arrangement for project management develops rather easily in a total engineering organization which has been established on a horizontal basis with functions established as individual departments. Members are drawn from the functional groups which will play a vital role in the engineering phases of the project and operate in a democratic atmosphere—each member having a voice in all major decisions. In cases of conflict or disagreement, problems can be settled at the next higher level by the "phantom team" of department supervisors who are always in the background to provide guidance and counsel. Indeed, if the problem still lacks solution at this next high-



Higher efficiency in the use of combined facilities such as laboratories, model shops and services is apparent

"Phantom team" of department supervisors are always in the background to provide guidance and counsel

er level, still higher levels of supervision are available to act as judge or final mediator.

This form of operation also has advantages and disadvantages which are interesting to note:

Advantages

It has a large fund of specialized knowledge. This results from the functional grouping of engineering specialties from which committee members are drawn. Each member in addition to being a working specialist also acts as a source of further specialty strength by being able to draw support from his affiliate department.

It brings a maximum number of ideas. The "two heads are better than one" adage operates to the advantage of a committee type operation, particularly when the member's departmental support is considered.

Makes better use of facilities and personnel. The higher efficiency in the use of combined facilities such as laboratories, model shops, and services is apparent. Further, specialized personnel are available in this system for application on more than a single project at a time. Of course, a possible danger of overloading specialists with assignments on too many projects must be recognized by supervisors and carefully controlled.

Better overall standardization. With committee members being drawn from functional groups, it is evident that their repetitive experience from project to project can bring a standardization of solution to like problems.

Minimizes duplication of effort. This is a corollary to the standardization advantage. By virtue of the committee member's supporting departments having the responsibility of handling their particular specialty for all projects, a problem occurring on more than one project will be solved once and in the same way for all projects.

Provides continuity of supervision. Since an employee always maintains his affiliation with the same specialty department regardless of the projects to which he may be assigned, he always reports to the same supervisor. This, when contrasted to the varying supervisory assignments an employee experiences when moving between projects organized along vertical lines, gives the individual a greater sense of employment stability and promotes a close relationship with his department supervisor.

Permits cross-checking and criticism. With a committee handling the technical and administrative problems of a project, the quality of work is generally higher and serious errors are greatly minimized.

Broadens personnel. With the exposure of each member to the diverse problems represented by the specialties on the committee, and the requirement that each member actively participate and share the responsibility for all phases of the project endeavor, the individual is naturally broadened as a professional man and tends to find his work more interesting and challenging.

Disadvantages

Department barriers grow up. This is apt to happen between members as a result of each man's tendency to contribute only his own specialty and to show a lack of interest or participation in the other fellow's work. "Buck-passing" is the natural outgrowth and evidence of this problem.

Responsibility is divided. Responsibility for the success or failure of the project is vested equally in each member. Hence, no one individual is "boss" and the requirements for fully cooperative operation by all members demands that there be a high degree of compatibility in the selection of personnel.

Diluted authority. The authority of the team over technical and administrative matters on their project is subject to the review of their respective supervisors. To avoid trouble, the members must recognize that their respective supervisors have a responsibility to higher levels of management. Further, the supervisors must recognize that their relationship with the committee consists of guidance, counsel, and technical policy, and that a dictatorial attitude from supervision nullifies the responsibility assigned to the committee.

Cumbersome communications. Communications are slower and more tenuous since the committee arrangement does not have the clear-cut direct information channels found in the vertical type organization.

Divided job allegiance. A committe member obviously can serve on as many projects as his time will allow. This can naturally lead to his operating in a self-generated preferential manner unless carefully controlled by supervision. Further, in cases of conflict between assigned projects, he can become confused and harried unless priorities are established by management.

Slower acting. This is the obvious defect in any

system of operation where decisions must be made by group effort. Any committee type of function is characterized by discussion. While this is not necessarily undesirable, it has a direct influence on the speed of operation.

To Strengthen and Improve

With these considerations in mind, the relative advantages and disadvantages of both the vertical organization and the committee organization were carefully weighed by Arma's supervisors from the standpoint of the corrective measures which might be taken to minimize or eliminate the disadvantages of either type of plan. It became apparent that the disadvantages of the vertical organization were rather fundamental whereas the disadvantages of the committee organization were more subject to solution.

It was therefore decided that the committee organization would be continued for the management of projects with the individual committees established and known as project teams. However, the study showed that measures must be taken to strengthen the project team, and a distinct effort must be made to delineate clearly the duties, responsibilities and authorities of both the engineers and supervisors involved in the operations.

To this end, round-table discussions were held by supervisors with all project engineers for the purpose of disseminating the results of the appraisal and stimulating an active interest in successful team operation. At these meetings it was carefully pointed out that the committee organization, like any organization, had disadvantages, which if given careful attention, could be minimized more readily than those of other types of project management methods. It followed, therefore, that by carefully studying each difficulty of project team operation, solutions were found to the problems of the adopted organizational arrangement. In large measure they were solved by clearly stating the objectives, responsibilities, authorities, and relationships of the project team with all sections of the Company. These were then published in an engineer's manual together with detailed company procedures for the overall guidance of team operations. The mere process of putting this information in writing went toward improving the effectiveness of project teams. A healthy stimulus was afforded to everyone involved by simply putting the problem on the table, taking it apart to understand it, and reassembling it in an improved form.

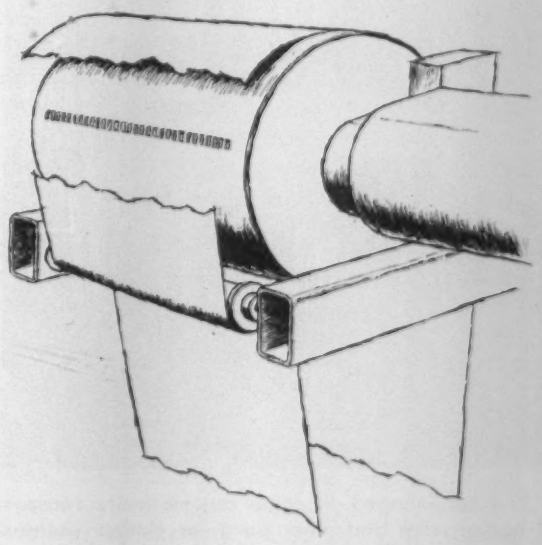
Obviously, successful project team operation, however organized, depends not only on the competence of its members but also on the measures taken to continuously measure its performance. A well-qualified group of engineers can indeed be depended upon to produce an adequate technical answer to the *How* of a project, but the other factors—*When* and *How Much*—require constant attention and evaluation. To this end a system of administrative controls must be established to produce answers accurately and continuously to these two basic questions. Without such a system a project can conceivably operate in a haphazard, inefficient manner to the end result of missed dates, financial loss, and unhappy customers.

How project administration can be measured and controlled is the subject of the next article.

STORAGE DEVICE FOR DATA PROCESSING

NEW TYPE of magnetic storage device or memory combines the advantages of drum and tape recorders. With each revolution, rotating heads in the drum scan information on a section of stationary tape which covers half of the drum periphery, and is separated from the drum by an air film. This can also be done with each half revolution if additional heads are provided in the drum. The section of tape so covered is referred to as a page; each page may contain up to 200,000 binary digits depending on the size of the drum, the width of the tape, the pulse packing, and the track width.

With conventional magnetic drums, additional drums are needed when storage requirements exceed drum capacity. In the TapeDRUM of Clevite-Brush Development Co. rollers advance the tape so that additional storage surface appears over the area scanned by the rotating heads. Large amounts of information can be stored with only a small cost increase for additional tape.



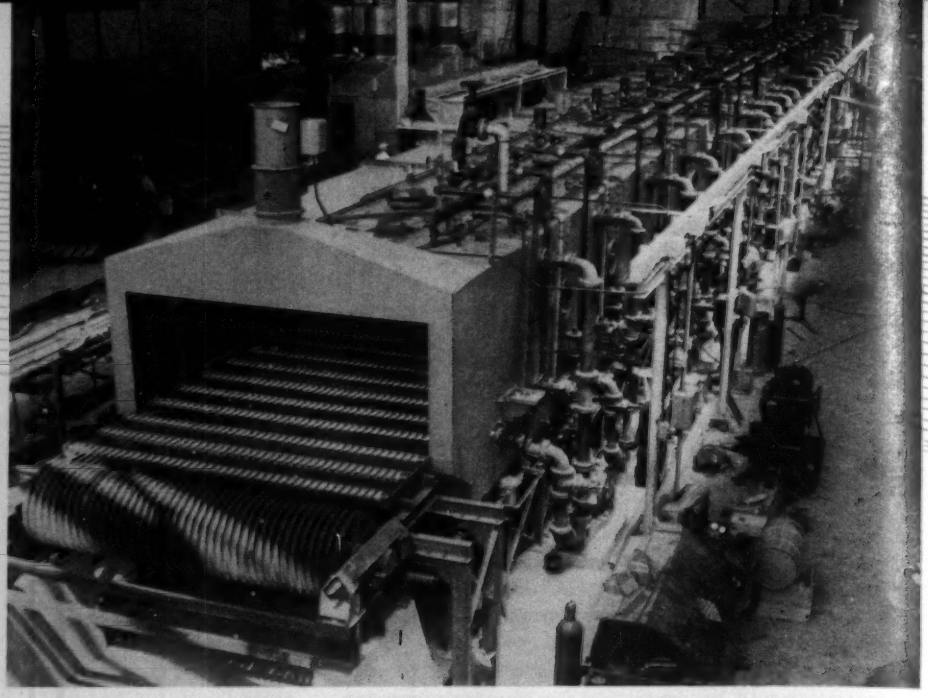
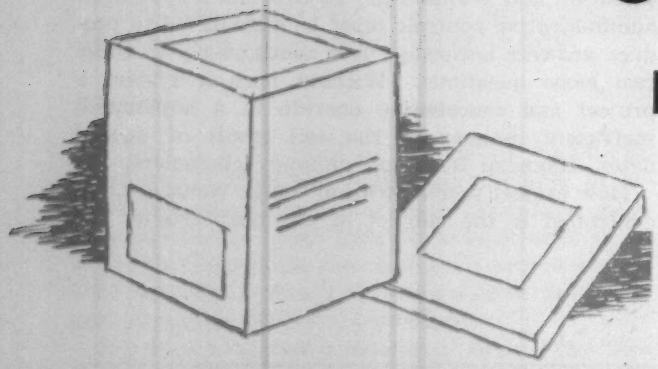


Fig. 1—Overall view of the automatic spray pickling and washing machine recently installed in the new Hotpoint Chicago plant. Fumes are eliminated sufficiently to allow stacks on either end of the machine to exhaust directly into the work area

SPRAY PICKLING

PERMITS CONTINUOUS



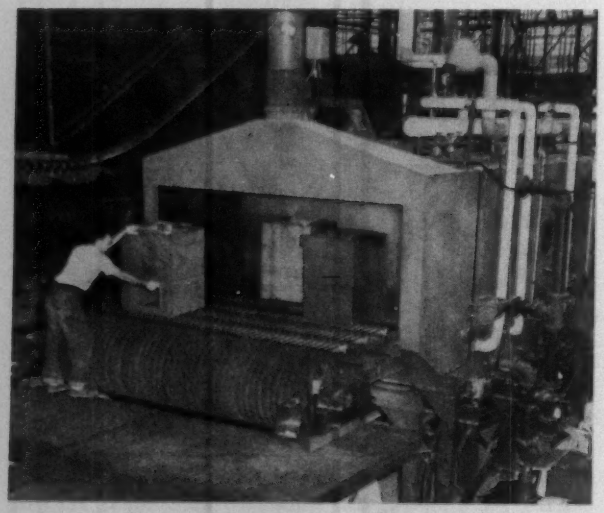
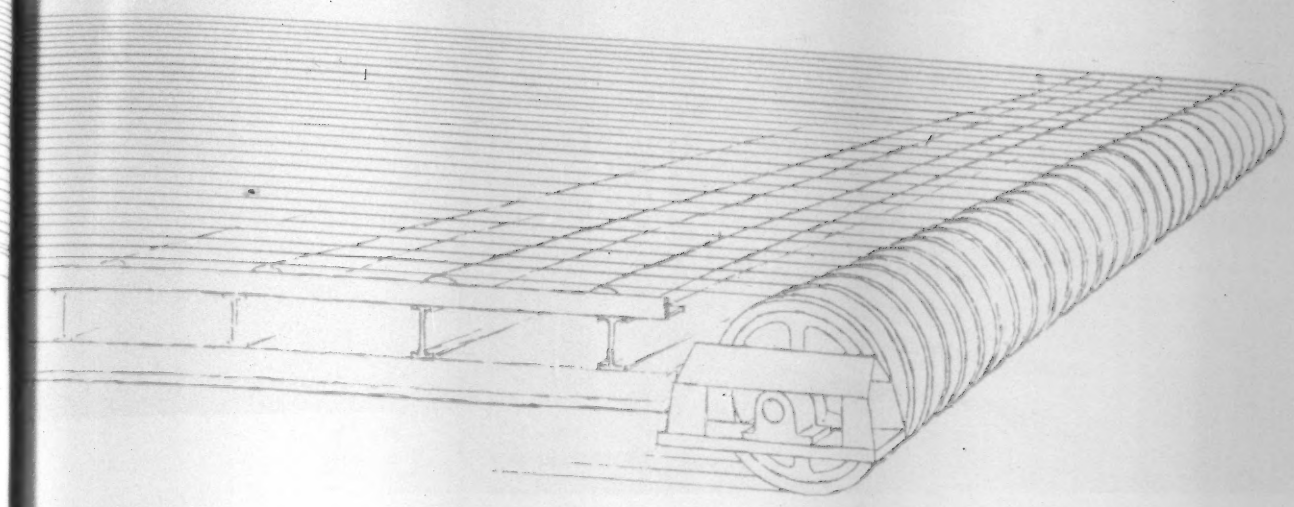


Fig. 2—Tunnel-shaped machine automatically conveys steel bodies, tops and other parts for clothes washers and dryers through a series of compartments where alkaline, acid, and nickel-sulphate solutions clean metal surfaces and prepare parts for porcelain enameling

AMERICAN INDUSTRY usually seizes upon a promising production development, whether foreign or domestic, and rapidly transforms it into another device to further increase output, reduce costs and improve product. Now and again, however, a process will remain hidden for a considerable time so that when it finally makes an appearance in industry, its newness has a history.

So it is with automatic spray pickling, a recent import to our industrial scene but a 30 year-old process to Edward Curran Ltd. of Cardiff, Wales. An agreement reached in 1944 with the B. F. Goodrich Co. introduced spray washing and pickling to this country, permitting Goodrich to build and sell these machines in the United States and Canada. This arrangement has resulted in a variety of both ferrous and nonferrous products being processed by this method.

Recent installation of the automatic spray pickling and washing machine at the Hotpoint Co. Chicago plant, *Fig.* 1, is typical (except for its size) of similar machines now coming into increasing use. The tunnel-shaped machine, 175 feet long, automatically conveys steel bodies, tops and other parts for clothes washers and dryers through a series of compartments where pressure sprays of alkaline, acid and nickel-sulphate solutions clean the metal surface and prepare parts for porcelain enameling.



AND WASHING PROCESS

METAL SURFACE PREPARATION

An endless conveyor made of rubber-covered steel cables moves parts through 11 separate operations in the machine. Interior surfaces of the machine are lined with rubber to protect them against highly corrosive action of the pickling acids. The multistrand conveyor eliminates the need for special fixtures to handle parts of various shapes and sizes.

Spray jets bring required solutions to the work more efficiently than can the open tank method. Chemical action of the acid, mechanical force of the jet and aeration effect of the spray accelerates the attack on oxides or scale, shortening pickling time by a factor of six in some cases. Processed parts are more uniformly treated, reducing the number of rejects considerably.

Recirculation of solutions has an effect similar to fresh chemicals being brought into contact with the work. It has been found that recirculating tanks do not require dumping nearly as often as still tanks. Quantity of chemicals needed has been reduced—alkali from 8 ounces per gallon for the old method to ¼-ounce per gallon in the new.

As washer and dryer parts move through the machine, a hot alkaline jet spray first removes all loose foreign material clinging to the surface of the metal. Next a sulphuric acid spray removes rust and scale and etches the surface to improve porcelain adhesion as does the following nickel-sulphate spray. Various hot and cold rinses separate these operations. A final spray of alkaline neutralizer rustproofs the metal for the several hours prior to enameling.

The acid section is in the center of the machine isolated by fresh water rinse-curtains at either end, which prevent acid fumes from escaping, *Fig.* 2. Trapped fumes contribute toward more effective cleaning of recessed parts. Headers and spray pipes are connected inside the machine to safeguard against acid leaks; spray pipes can be adjusted to any desired angle by hand.

Labor required to operate this machine is reduced compared to dip methods. One or two operators at either end of a machine are sufficient, and even these loading and unloading operations could be automated. Greater speed of pickling, and the number of operations involved without handling reduces labor costs considerably. Maintenance costs are exceptionally low. Routine packing of pumps, lubrication, and occasional repair of conveyor cables make up the greater part of these costs. Because of the absence of fumes or splash, the pickling operation may be placed in the production line. This type of pickling machine can be directly connected to a furnace or other piece of equipment by an interlaced conveyor in the main building of a plant instead of being operated "out in the pickling shed."

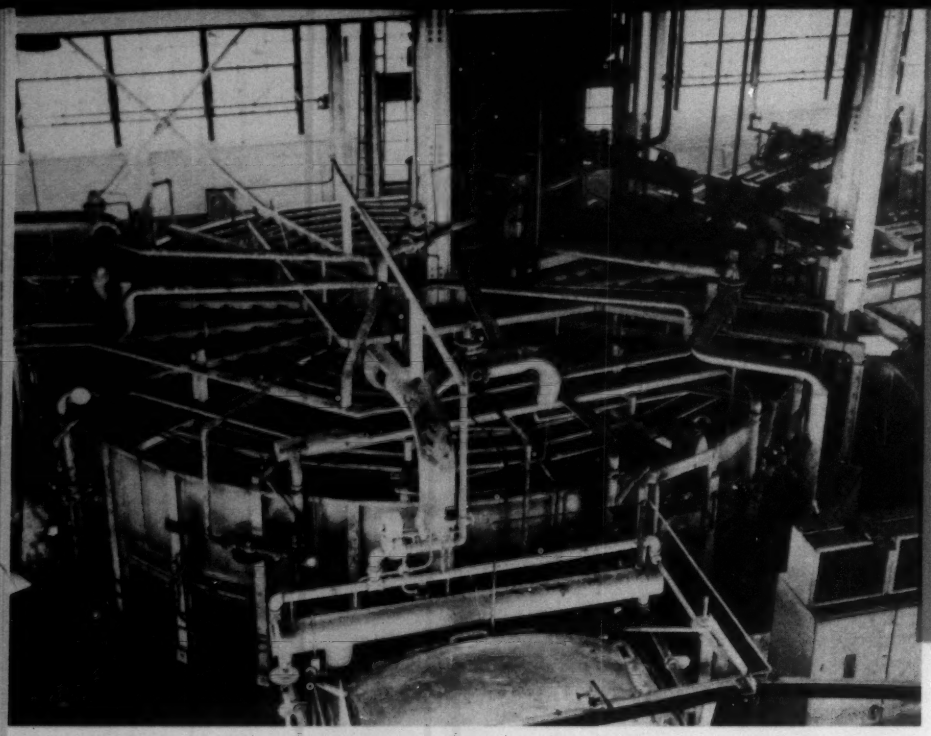
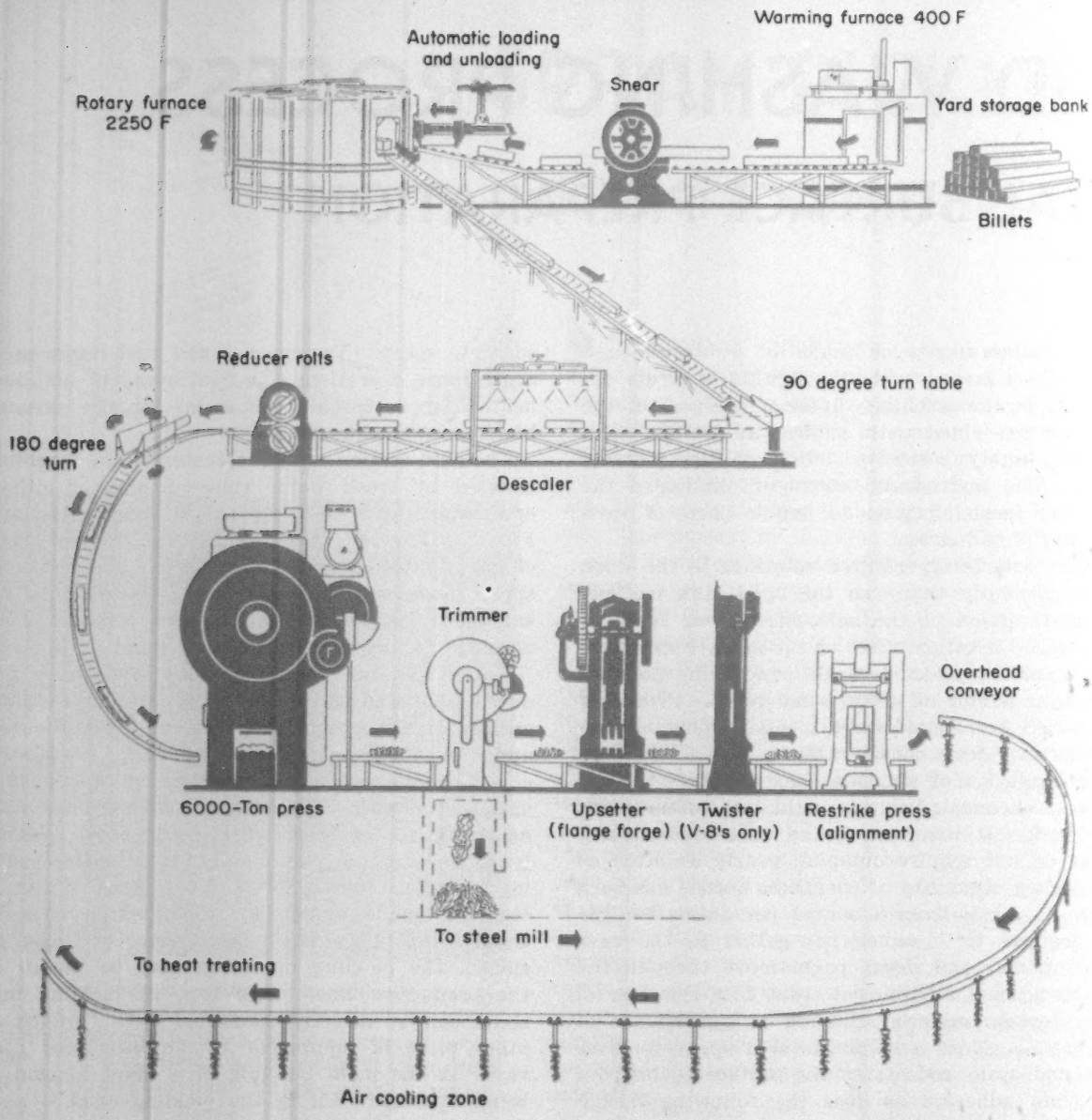


Fig. 1—Overhead view of the automatic rotary furnace used in the crankshaft press shop of the Dodge forge plant. This furnace, 32 feet in diameter, receives, heats to forging temperature and discharges steel billets automatically at rates up to 300 an hour



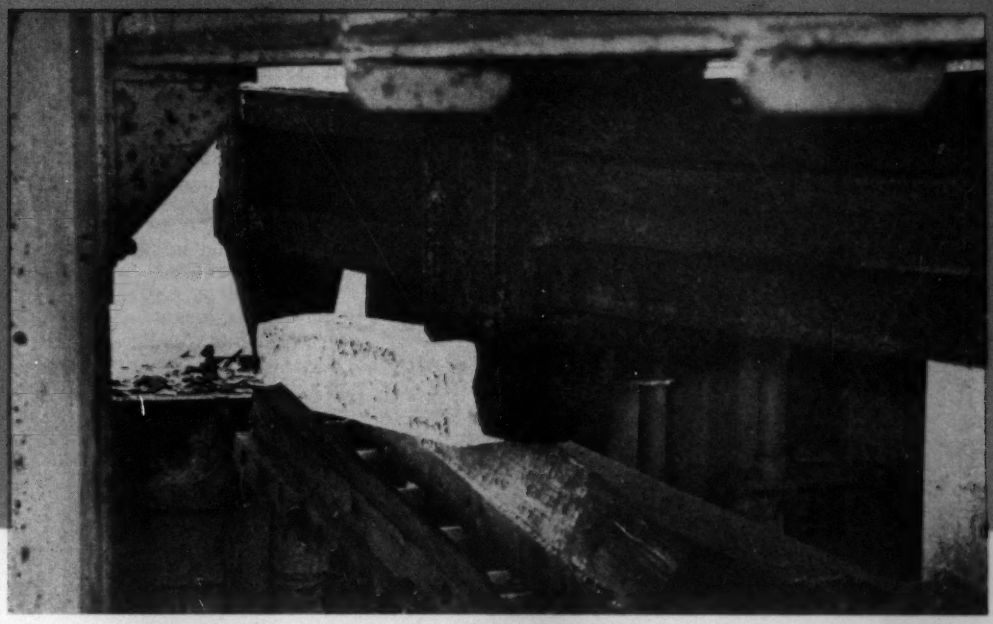


Fig. 2—Automatic unloading hands remove a steel billet heated to 2250F from the automatic rotary heating furnace. These hands seize, lift and remove white-hot billets without sliding them over the furnace floor. Entire operation of feeding, loading and furnace indexing is hydraulic and mechanical with electric synchronization

HANDLING MECHANISMS AUTOMATE PRESS FORGING OF CRANKSHAFTS

CONTINUOUS PRESS forging is more suited to automation than the older hammer forging methods. Because of this, the steam hammer is being replaced in automotive forge shops by powerful rolling machines and mechanical and hydraulic presses integrated into co-ordinated lines by automatic materials handling devices. Forging of crankshafts in the Dodge forge plant has followed this trend and demonstrated the suitability of press forging to automation.

Magnetic cranes pick long steel billets—not the expensive preformed shapes once required—from the storage yard to start a seven-hour journey through the forge. Billets are placed on a rack from which a hydraulic ram pushes them through a warming furnace, used principally during cold weather to warm billets in order to avoid cracks from shearing. A conveyor carries them to the shear which slices off 106 to 125-pound sections. Smaller pieces make shafts for six-cylinder engines, larger ones for eights. An operator determines size, but progress through the shear is automatic.

Next stage is a 32-foot fully automatic rotary furnace, *Fig.* 1, in which billets are heated to 2250-2300 F. A turning table is indexed in small angular movements so that a space is always ready for the next conveyor-borne billet. An elevator raises a billet to the furnace door and as the fur-

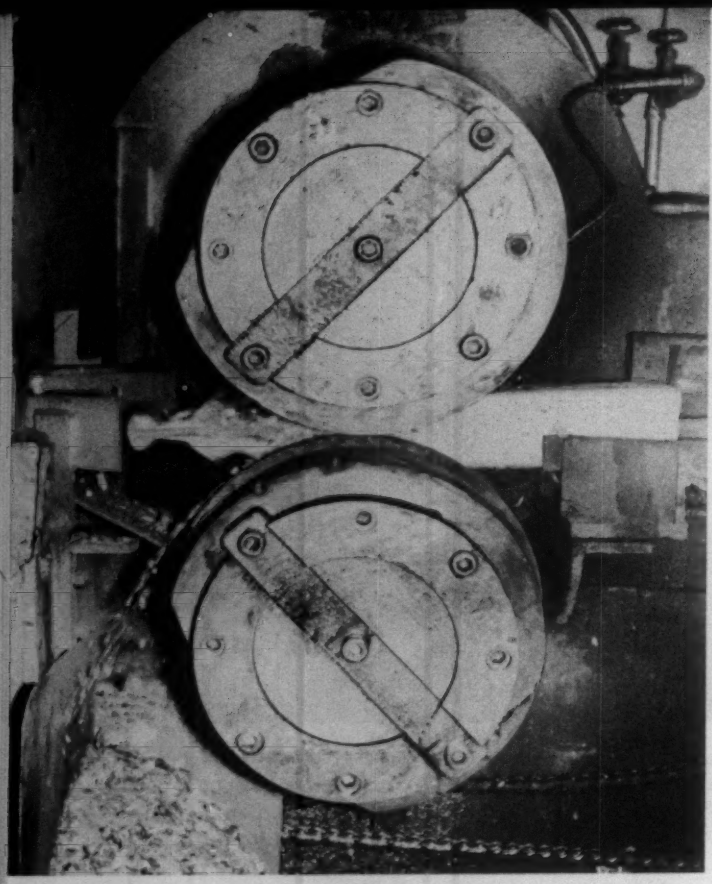


Fig. 3—After being heated to forging temperature, crankshaft billets are conveyed automatically to these reducer rolls. As a billet passes through the rollers it changes from an oblong shape to a configuration which distributes the metal in places needed for subsequent press forging operations

nace table halts momentarily, a hydraulic hand lifts the billet, the furnace door opens, and the billet is inserted. As many as 300 billets an hour can be processed.

Another hand removes white-hot billets, *Fig.* 2, and deposits them on a conveyor for transmission to the descaler, where they are cleaned by a blast of water at 1500 to 2000 psi. Next, reducer rolls squeeze the metal into rough shape, *Fig.* 3, after which they are moved automatically, as shown in *Fig.* 4, to a 6000-ton mechanical forging press.

An operator grasps a billet with tongs and moves it into the first forging position, *Fig.* 5. A die presses the metal into a rough shape that begins to resemble a crankshaft. A quick roll through jets of water, a second strike of the press, and the piece is pushed out the rear.

A smaller press, *Fig.* 6, trims off the flash and an air cylinder pushes the forging out. Flash is dropped into a tunnel conveyor for delivery to waiting freight cars. The same tunnel carries two sets of ducts, one carrying off fumes, the other bringing a constant supply of fresh air to the operators.

Still moving by conveyor, forgings go to an upsetter for squeezing a flange on one end. V-8 shafts, which are forged flat, then move to a hydraulic twister, *Fig.* 7, which gives proper alignment. A restrike operation confirms this alignment. After straightening the forgings are placed on a rack to be picked up by overhead conveyor for cooling and heat treating.

Each shaft takes seven to eight hours to forge, but shafts move through in a continuous flow at less than 30-second intervals. Results include:

1. Production increases of 100 to 200 per cent.
2. Improved uniformity of quality with fewer rejections.
3. A 5 to 10 per cent reduction in scrap and machining losses.
4. Substantially lower unit manufacturing costs.
5. And for workers, a drastic reduction in manual handling—a perennial source of danger; a reduction in line jobs and an increase in maintenance work.

Though less strenuous, work in such a plant places a greater degree of personal responsibility on workers. The plant manager has stated, "We now need people who can suggest improvements, not mere button pushers. Maintenance people here are not only on the job to fix things as they break. They are here to see to it that things don't break."

As in so many other sections of the industry, the automotive forge plant is placing greater reliance upon intelligence, and less upon years of training in performance of repetitive mechanical motions.

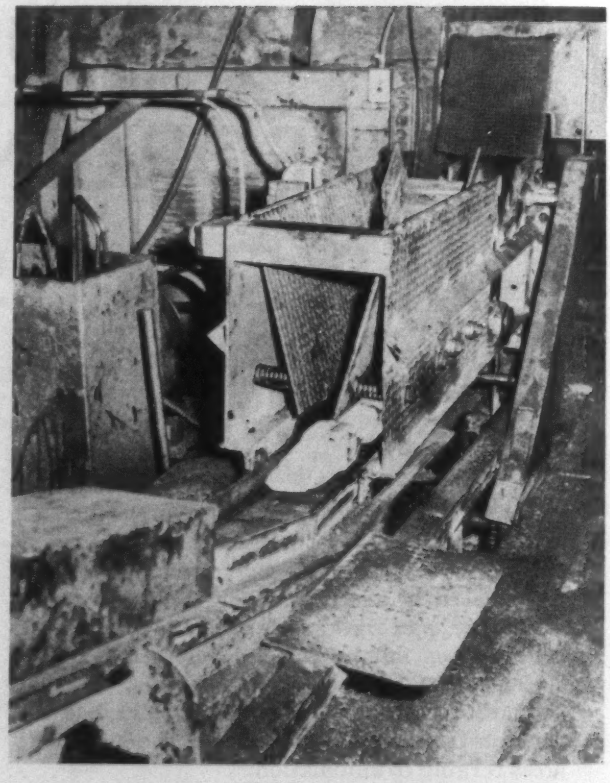


Fig. 4—An air driven piston actuated by a photocell has pushed the billet end-over-end to orient it in position to enter the 6000-ton mechanical forge press

Fig. 5—Only two strikes, one on each of two dies, are required to forge the crankshaft being handled by the operator. Forging is transferred from one die to the other through the water spray

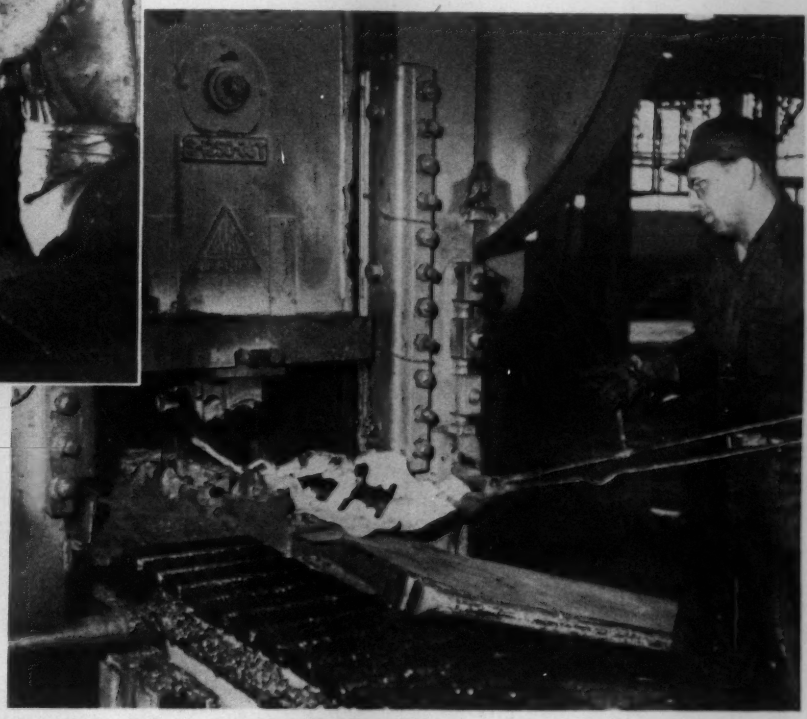


Fig. 6—After press forging, crankshafts move to a trim press that separates flash from the forging. Flash is carried off by a conveyor running to an outside scrap pile or waiting railroad cars for shipment to the mills

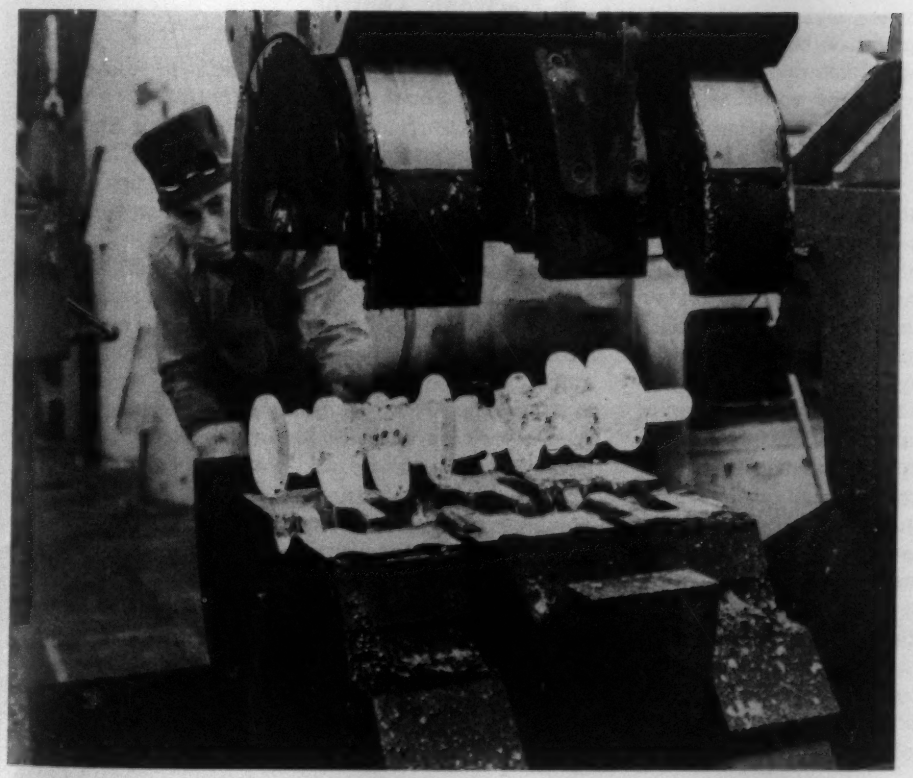


Fig. 7—Crankshafts for V-8 engines are forged flat; this machine twists the forgings to place crankpin bearings in proper alignment

ELECTRONIC TAPE CONTROL SYSTEM

USES STEP MOTOR DRIVE

BY A. G. THOMAS
Industrial Controls Corp.
Chattanooga, Tenn.

TAPE CONTROL devices for machine operation are now accepted components of production in a number of industries. Impetus toward simplification and reliability will certainly bring wider usage for these systems, especially to the small and medium-lot producer and precision job shop. It will be interesting indeed to see whether modern tape control systems developed for metalworking machinery and machine tools will be adapted for use in fields such as textiles, computers and printing where tape control has a long history.

An automatic control system has been developed by the Industrial Controls Corp. of Chattanooga, Tenn. to provide automatic tape operation of milling machines, lathes, grinders, drills and other machine tools. Tape is the control medium but other recording means, such as punched cards, may be designed into the system if desirable.

Underlying principle of this control system is that one mark or other characterization on the tape corresponds to one step movement of a motor. Any number of motors, therefore, can be controlled by the co-ordinating tape which can vary in speed without affecting the accuracy of the workpiece being shaped. This might be compared to an electrical gear system—motor responding to tape information step-by-step. Steps can be made so fine that the workpiece formed by the cutting tool is relatively smooth. In the automatic milling machine shown in *Fig.* 1, each step movement causes work displacement of slightly less than one mil. By using a different gear ratio, displacement per step could be a tenth or any other desired value.

Electronic Control

Three identical electronic units in the control cabinet, and three step motors cause the table to travel lengthwise, the saddle to carry the table at right angles and the knee to lift or lower the workpiece. Other step motors may be used to raise or lower the tool or for additional automatic functions such as rotating or tilting.

This system is unique in that there is no hunting, nor is feedback used. Information on the tape determines final shape of the workpiece regardless of change of tape speed, changes in components, change of temperature, or other factors. However, feedback can be incorporated in special cases where yielding of metal or other changes of references might occur.

Nine thyratrons are used to control the milling machine for three-dimensional movement. A reel of 35 mm punched film is used to program the machining information which is sensed by photocells. A light bulb above the sprocket-driven tape signals the photocells; their outputs are fed to the grids of small amplifier tubes controlling the thyratron grids. In effect, then, punched tape serves to modulate light reaching the photocells which, in turn, control the thyratrons.

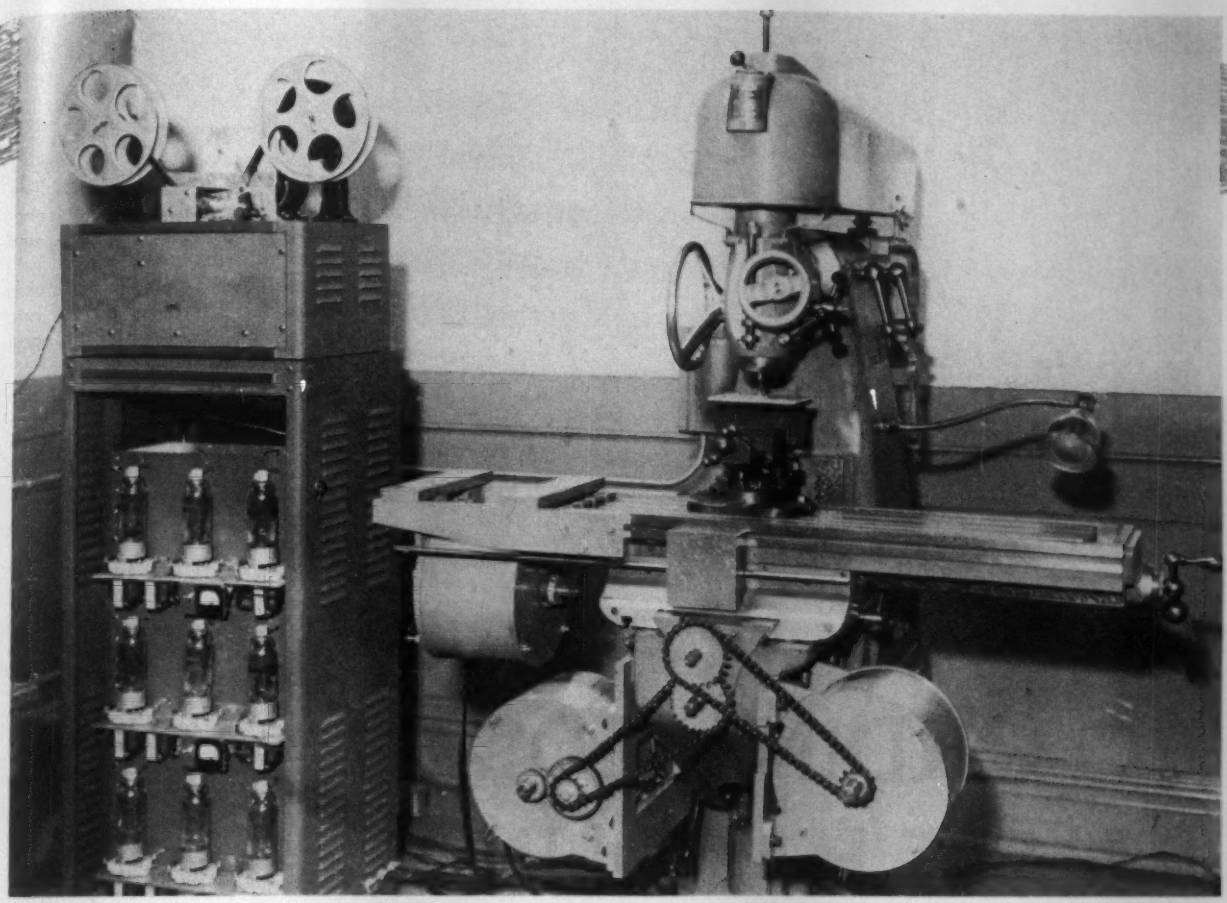


Fig. 1—Experimental tape controlled milling machine showing tape reading device, thyratrons, and three step motors to feed the workpiece. The electronic circuits that power the step motors are the power amplification means for tape sensing signals

Three phases of each motor on the machine are so arranged that when three associated thyratrons are fired in order, the stator windings are energized and the rotor revolves in steps. Motor speed is inversely proportional to the longitudinal spacing of holes—increased spacing decreases speed. Firing thyratrons in reverse order causes the motor to reverse.

A combined indexing and power device, the step motor is the key component in this automatic control system. Rotor and stator poles are relatively positioned so that the three-phase motor will start with the rotor in any position. Ordinarily rotors are not wound but can be to provide maximum torque in a limited space. The number of poles in each stator and rotor phase of the three milling machine motors was arbitrarily chosen at 36 providing 108 steps per revolution.

This type of motor has been built, however, with many more steps per revolution so that each step represents a relatively smaller angular displacement of the rotor. Conversely, motors can be operated with only a few poles and built in sizes ranging from inch-ounces of torque to thousands of inch-pounds. High starting torque and accuracy in indexing are characteristic, and when stopped, the motor is locked magnetically, suggesting rotary or lateral indexing applications for cutting gears or slitting and boring in precise locations.

Total of 20 electronic tubes, including photocells, thyratrons, and amplifier tubes, and a few relays are included in the milling machine control. Thyratrons pass 3.2 amperes average current but the motors can be satisfactorily operated with considerably less current for this application. Cutting speed with the present setup is about 18 inches per minute and can be materially increased if necessary. The motors have been run at speeds corresponding to cutting speeds of about 100 inches per minute with a gear ratio providing one mil displacement per step. Individual step movements are visible at motor speeds less than approximately 30 rpm but above that speed rotation appears to be continuous.

Suggested applications of this electrical servosystem in areas other than machine operation are in telemetering, computers, synchronized drives, valve controls and power amplification generally. The combined ability to control displacement and produce the power to do so makes the system a basic control device.

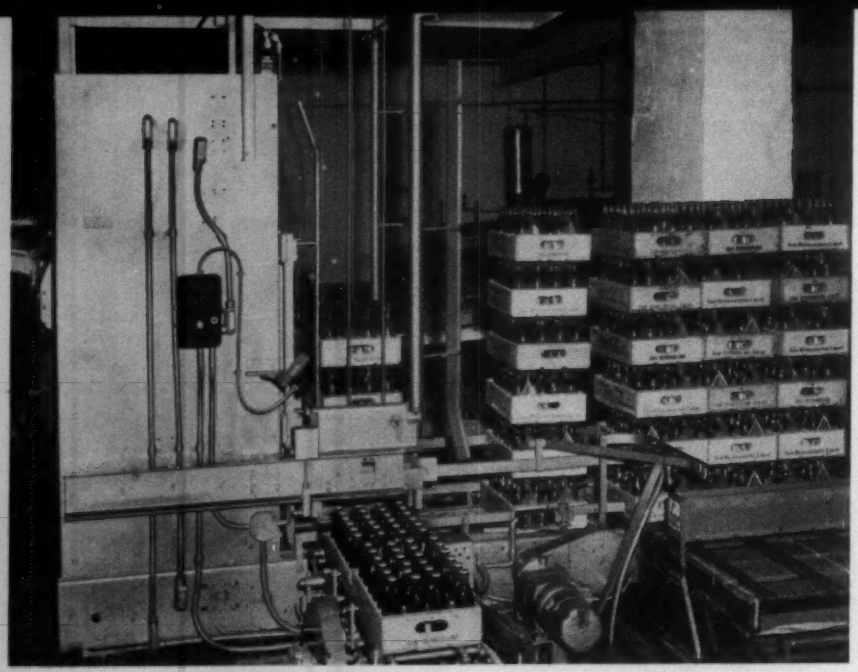


Fig. 1—Pallet handling machine which can unload pallets containing cases of empties and load the same pallets with full-bottle cases. Empties are being unloaded from the pallets and unstacked while full bottle cases in the foreground wait

CO-ORDINATED PALLET HANDLING

PAYS FOR ITSELF

REDUCTION in manual handling, high labor turnover and product damage can be realized by automatic pallet loading and unloading. Materials handling engineers of Food Machinery & Chemical Corp. and the Coca-Cola Co. have found this to be true in a San Bernardino bottling plant with a hydraulic machine which palletizes or depalletizes up to 1000 cases per hour.

After filled bottles are cased, they move by conveyor to the pallet loader where they are stacked to a pretermined height of between four and seven cases and then ejected as a stack to the accumulator. When three stacks are so located side by side, a hydraulic slider arm gently pushes them onto the pallet. After six stacks are loaded on the pallet, it is moved by roller conveyor to be picked up by a fork lift and transported to storage areas. Empty pallets are placed in position by the fork lift and are automatically fed into the machine.

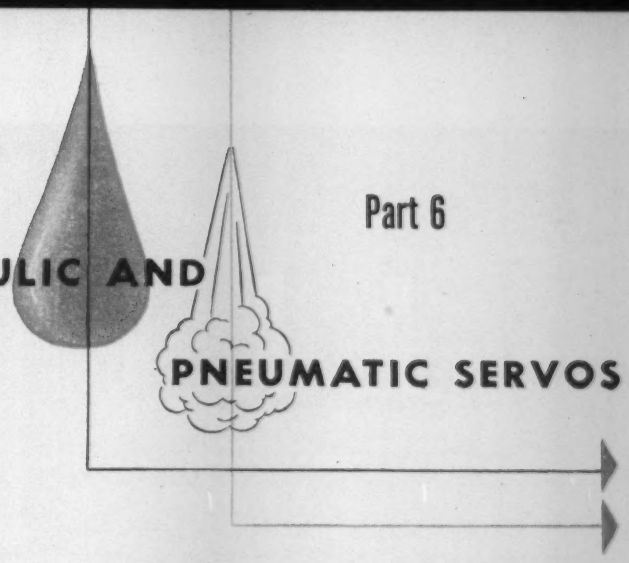
Empty-bottle cases delivered on pallets can be unloaded and unstacked simply by turning a switch to *Unload*. Cases of empty bottles are moved from the pallet onto the accumulator, three stacks at a time, by the slider arm. Stacks then move, one at a time, into the machine and cases are unstacked from a height of one to seven cases and conveyed to the bottle washer.

In an operation which requires loading and unloading in the same area at the same time, the machine can unload cases with empty bottles then load full-bottle cases, using one pallet for both operations. By setting the control knob on *Auto*, this sequence will continue as long as pallet loads of empties and full-bottle cases are fed to the machine.

Stop bars automatically control entry of cases into the machine and regulate loaded pallet movement away from the machine to lift trucks. If a broken case jams entry or discharge, the machine shuts itself off. If an empty pallet is not in the loading area, the machine will fill the accumulator with three stacks and automatically shut off.

Although the machine was originally designed to handle soft drink cases, with slight modification it can handle almost any rectangular item stacked on pallets in noninterlocking patterns.

By R. HADEKEL
Engineering Superintendent, Hydraulics
Sperry Gyroscope Co., Ltd.
Brentford, England



Part 6

HYDRAULIC AND PNEUMATIC SERVOS

COMPLEX SERVOS

Analytical theory and the basic principles for improving performance of hydraulic and pneumatic servos given in previous articles of this series, now serve as background information for launching into a comprehensive discussion of the special design considerations encountered when dealing with complex servomechanisms.

COMPLEX SERVOMECHANISMS will most frequently still embody a final power stage consisting of a motor controlled by a valve or variable delivery pump. This power stage together with the load can in practically all cases be treated as an irreversible group of components, in the sense that its input signal, the travel applied to the pump or valve, is entirely determined by preceding components in the chain. In this case Equations 30 and 36 respectively (See Part 5—AUTOMATION, Feb. 1955) are the transfer functions for the power stage and load, and may be used as such in the analysis of the complete system. The transfer function for the complete loop will usually be too complex to allow the derivation of simple stability criteria in analytical form, as in the preceding section. Analysis will then usually be based on frequency response methods, as explained in Part 2 (AUTOMATION, Nov. 1954).

As later examples will show, the stages preceding the final power stage may be similar to the latter, and consist of a valve and miniature "motor" in the form of a piston actuating the power valve. Such preamplification stages handle only quite low powers, and compressibility effects can be safely neglected. Furthermore, it is usually possible—and desirable—to make the load pressure in these early stages low in comparison with the supply pressure. Under such conditions a valve-motor combination can be treated as linear, its transfer function being simply of the form K/s. Other components such as networks may also be treated as linear and irreversible in most cases. Under such conditions the derivation of the loop transfer function of a complex servo presents no particular difficulty. If the final power stage is valve controlled and the power is high, the transfer function will make use of Equation 36, and

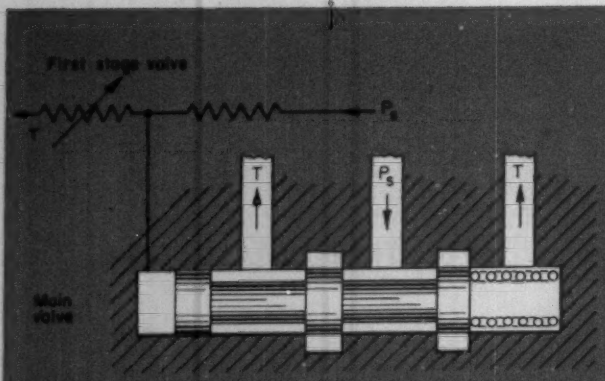


Fig. 74—Preamplifier of the pressure-controlled type, consisting of a potentiometer valve arrangement actuating a spring-loaded piston, which is the spool of the main valve

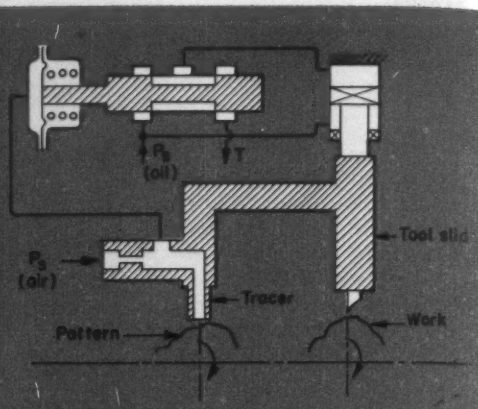


Fig. 75—Hydro-pneumatic system for copying machine tool avoids contact between tracer and work, allowing plaster patterns to be used

will therefore apply for small perturbations only.

Examples of relatively complex servos are:

1. Regulators or process controllers which most often must have networks to produce some specific transfer function, matching that of the plant which they control. The complete loop consists of regulator and plant.
2. Servomechanisms embodying networks or subsidiary loops for the sake of achieving better response.
3. Servomechanisms which make use of electrical data transmission gear and/or electrical transducers, the transfer functions of which must be taken into account. In some cases, the servo may be actuated by a gyroscope, which also has its own response characteristic. Examples are naval gun controls, and aircraft automatic pilots. In the latter case the response of the aircraft to control surface movements must be taken into account. In all these examples the available load from the data transmission gear, transducer or gyroscope is very low, and insufficient to actuate a valve handling high powers. Some form of preamplification is therefore the rule.
4. Servomechanisms which must have zero velocity error; these are common in gunnery.

Examples 2, 3 and 4 can, of course, occur in various combinations.

Preamplifier Systems

An additional amplification stage in front of the main power stage may be used to increase the available force to actuate the latter, as in the cases mentioned above. It may also, at the same time, fulfill a second function, namely producing a zero steady-state velocity error characteristic. This latter case will be treated later. The present discussion will be concerned with preamplifiers used only as a means of increasing force.

One convenient method of achieving this end is to use a preamplifier of the pressure-controlled type, consisting of a potentiometer valve arrangement actuating a spring-loaded piston, a typical arrangement being shown in *Fig.* 74, where the piston is formed by the spool of the main valve. Systems of this type are particularly convenient when the first stage is pneumatic, which may be advantageous for some applications in which the pneumatic valve may be used as an error-detecting device. For instance, in some copying machine tools the first-stage (pneumatic) valve forms the tracer, as shown in *Fig.* 75. Direct contact with the pattern is thus avoided, and plaster patterns may be used. A somewhat similar method is used in some aircraft automatic pilots, in which the gyroscope casing is connected through a fixed resistance to a vacuum system. Movement of the outer gimbal ring causes progressive closing of the control orifice, which communicates with the atmosphere, and thus changes the pressure inside the casing. This condition is communicated to a diaphragm which actuates a hydraulic valve, *Fig.* 76. The jet from the orifice is also used to drive

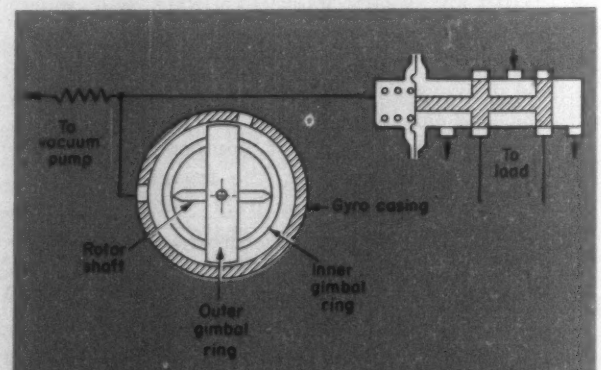


Fig. 76—Hydro-pneumatic system picks off gyro position in aircraft automatic pilot

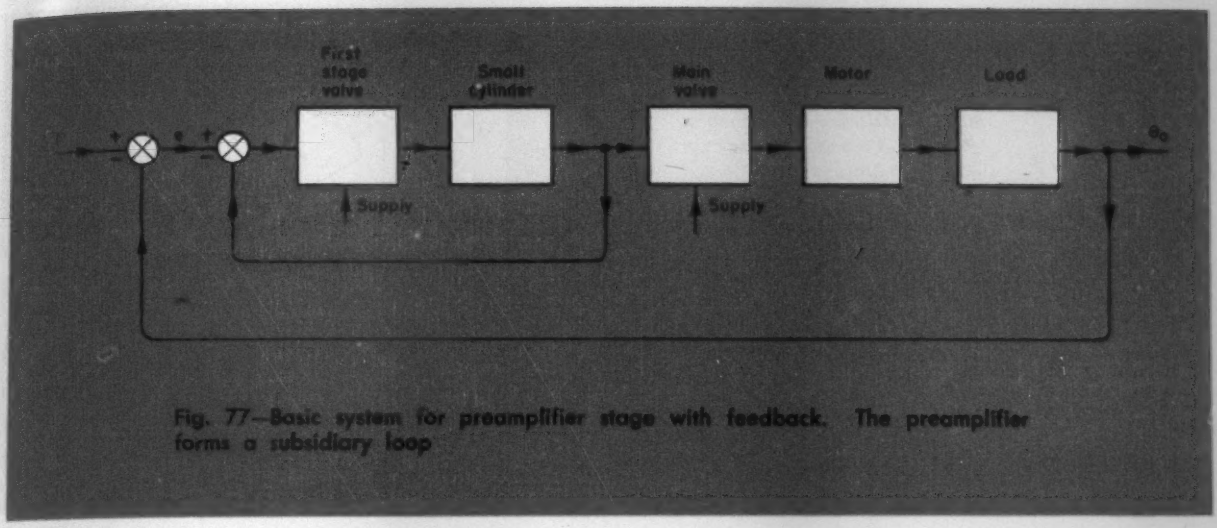


Fig. 77—Basic system for preamplifier stage with feedback. The preamplifier forms a subsidiary loop

the gyroscope rotor. Vacuum is used in preference to pressure chiefly to avoid contaminating the gyroscope with oil or water.

Pneumatic error detection is of wide applicability, and will probably find many more uses in the future. Among existing applications might be mentioned edge position control systems for machinery winding paper, sheet metal, or any other continuous sheet material. For many such applications, pneumatic error sensing may be quite as effective as a photoelectric system and much simpler and more convenient.

Another useful method of preamplification is to use an ordinary flow-controlled valve servo as force amplifier. This is almost always the practice in the case of variable delivery pump controlled servos, as illustrated in *Fig.* 56 (See Part 4—AUTOMATION, Jan. 1955), but is also applicable to valve-controlled power stages. The basic block diagram is shown in *Fig.* 77, the preamplifier forming a subsidiary loop. In practice the preamplifier servo may be considerably simpler than that illustrated in *Fig.* 56, as the cylinder is formed by the main valve, and feedback may be obtained by forming the body of the preamplifier valve inside the spool of the main valve. A neat construction of this kind is shown in *Fig.* 78, which shows the valve used in some of the German Siemens automatic pilots. The first stage is in effect a Wheatstone bridge type, as illustrated in *Fig.* 48, with the three fixed resistances being in the form of orifices in the outer lands of the main valve. This type of valve required an operating load of less than 5 grams, and although originally designed to handle only 45 watts was later used in gunnery servos to handle several horsepower[17]. A preamplifier system on the same principle, but using an Askania type nozzle as the first-stage valve, is shown in *Fig.* 79.

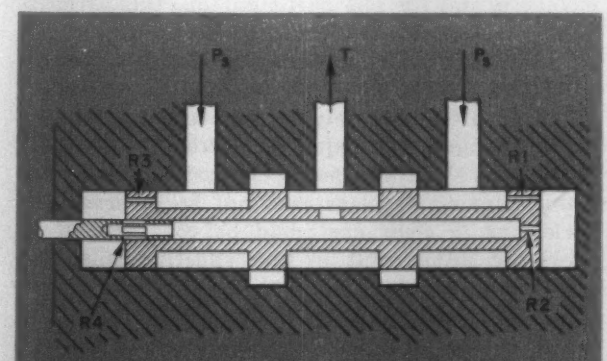


Fig. 78—Two-stage valve system used in the German Siemens automatic pilots; first stage is in effect a Wheatstone bridge type

▶ Network Elements

Signals at the various stages in pneumatic and hydraulic servos may be hydrostatic pressures or flows, or they may be mechanical displacements or forces applied to valves or pumps. Some networks may deal entirely with purely mechanical quantities such as displacement or force, as for instance the network shown in *Fig.* 3 (See Part 1—AUTOMATION, Oct. 1954), which gives phase advance to a mechanical displacement. Networks of this type will be called mechanical networks, as opposed to hydraulic or pneumatic networks, which handle pressure or flow signals.

In electric networks, examples of which have been shown previously in *Figs.* 10 and 13 (See Part 2—AUTOMATION, Nov. 1954), the basic elements are usually resistances and capacities, inductances being used only rarely. The mechanical analogs of resistance and capacity are dashpots and springs; the mechanical analog of inductance

[17]References are tabulated at end of article

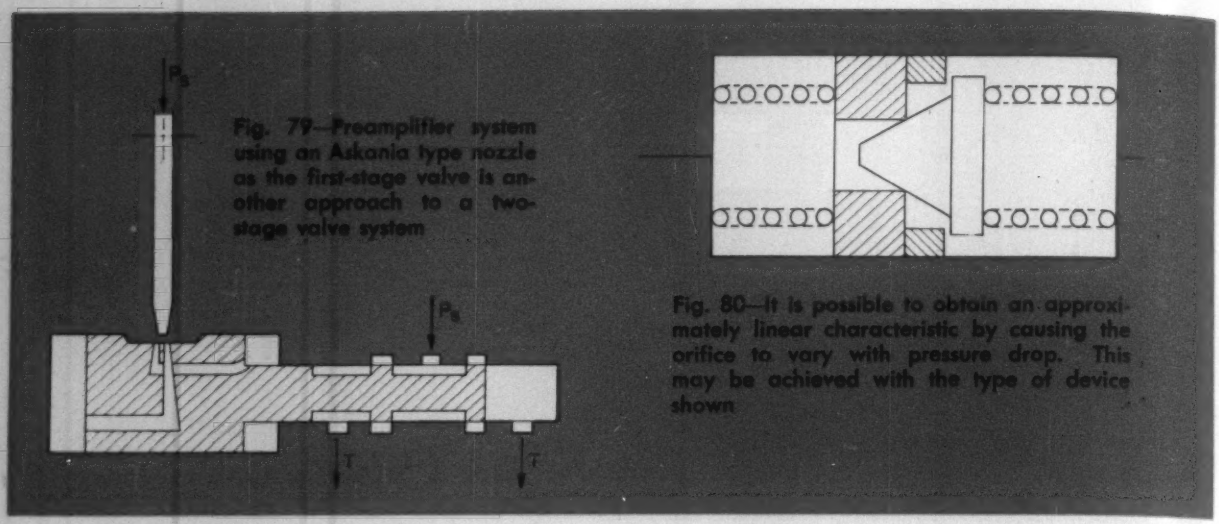


Fig. 79—Preamplifier system using an Askania type nozzle as the first-stage valve is another approach to a two-stage valve system

Fig. 80—It is possible to obtain an approximately linear characteristic by causing the orifice to vary with pressure drop. This may be achieved with the type of device shown

is mass, but mass elements are quite impracticable for servo networks. The hydraulic or pneumatic analog of electrical resistance and capacity is hydraulic (or pneumatic) resistances and capacities.

Hydraulic or pneumatic resistances may be of the orifice or of the viscous type. Orifice resistances are highly nonlinear, the pressure drop varying as the square of the flow. This characteristic is undesirable since the effective resistance is negligible for small signals, and hence orifice resistances are unsuitable for networks. It is possible to obtain an approximately linear characteristic by causing the orifice to vary with the pressure drop. This may be achieved with the type of device shown in *Fig.* 80, in which the orifice increases with pressure drop as the valve (or seat) is pushed back against the spring; the load in both springs must be just zero when the orifice is closed. The characteristics of this device are shown in *Fig.* 81. The curve is vertical at the origin, which means that the effective resistance is rather high when the signal is weak, which can probably be tolerated. Devices of this type have been used for many years in automobile shock absorbers for exactly the same purpose—approximating linearity. The author has not seen them applied in servos, but they will be worth using in some cases in preference to viscous resistances, as they are less bulky and almost insensitive to temperature.

Viscous resistances are quite linear and are obtained if the velocity is relatively small, the passage narrow, and of substantial length. In pneumatic process controllers viscous resistances often consist of needle valves or lengths of capillary tubing, the length being varied to alter the resistance, which must be adjustable in this kind of application. In needle valves the gaps are so small that the calibration is seldom reliable. A more consistent device has been found to be a flattened tube, which is bent to decrease the gap. Viscosity of air varies as the square root of the absolute temperature, and hence in pneumatic systems the temperature effect on resistance is quite low, and is invariably left uncompensated.

Hydraulic viscous resistances may be formed for instance by a pair of mating cylindrical members, with a clearance of at most a few thousandths of an inch. The two members must be kept concentric, as eccentricity may reduce the resistance by a factor as large as 2.5. The device must be large enough to keep velocity low, otherwise orifice losses would become excessive and the linearity would become seriously impaired; hence if the maximum flow is large the resistance may become somewhat bulky.

Hydraulic viscous resistances are highly sensitive to temperature, and some form of compensation is usually provided. One method is to use a pair of components made of dissimilar metals, so arranged that the difference in their thermal expansion reduces the gap as temperature increases. A good combination is an aluminum alloy inner member in a steel body; with cylindrical members, and for one particular oil, this arrangement gives quite close compensation over a range of more than 30C, provided the radial clearance is exactly 0.00085″ per inch diameter. As the resistance varies inversely as the cube of the gap, this arrangement requires extremely accurate manufacture. In an uncompensated resistance the manufacturing problem need not be so severe, as variations in clearance could be counteracted by providing adjustment of the effective length of the flow path.

Another method of thermal compensation[7] is shown in *Fig.* 82. The resistance used in the network is the clearance at *A*. The left-hand chamber is fed from a fixed pressure source, and consists of a viscous resistance formed by the gap at *B*, and an orifice resistance at *C*, the outlet from which is at atmospheric pressure. The piston will move until pressure drops at *B* and *C* attain a

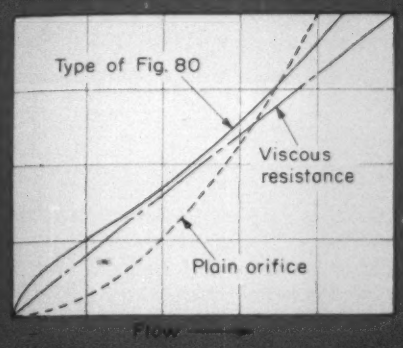


Fig. 81—Characteristics of Fig. 80 and of other hydraulic resistance elements

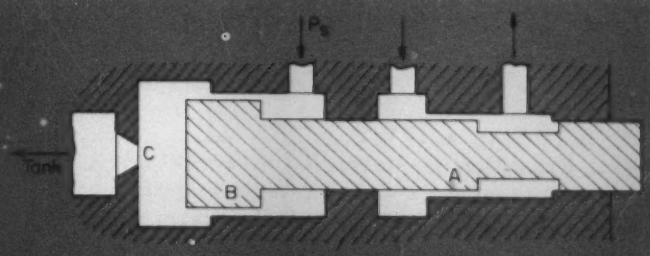


Fig. 82—Viscous resistance with temperature compensation; a small range of adjustment is obtainable by varying orifice

fixed ratio depending on the ratio of areas on the two sides of the piston. The orifice resistance at C being practically independent of temperature, the resistance at B must also adjust itself to a value independent of temperature. The lengths of the paths at A and B are made equal, and must therefore remain equal in all positions. Hence the resistance at A will bear a fixed ratio to that at B, and will also be independent of temperature. A small range of adjustment is obtainable by varying the orifice.

Third method of compensation is shown in *Fig.* 83, which is self-explanatory. The gap must bear a fixed relation to the length of the compensating rod, and this is achieved by means of the adjusting screw. The resistance may be adjusted without upsetting the compensation by sliding in the beveled member, as shown.

In pneumatic systems any volume of air in itself forms a capacity. If the air is contained in an elastic envelope, say a diaphragm or bellows, additional capacity results from this, but in most cases this effect is of relatively low order, and may legitimately be neglected. Hydraulic or pneumatic capacity is defined as the volume of fluid required to produce unit change of pressure. For a mass of air M at a pressure p in a vessel of volume V, at an absolute temperature T then $pV = MRT$, where R is the gas constant. If an additional mass δM is supplied under isothermal conditions, the rise in pressure is given by $\delta M/\delta p = V/RT$. If δM is small in relation to M, the relative change of pressure is small, and an addition of mass M corresponds to an addition of volume $\delta V = RT\ \delta M/p$. Thus the capacity of the vessel is $C = \delta V/\delta p = V/p$.

The assumptions of small changes made above apply under the conditions in which capacities are used in pneumatic process controllers.

In hydraulic systems the elasticity of oil, though sufficient to cause stability troubles, is far too small to provide useful capacities where these are

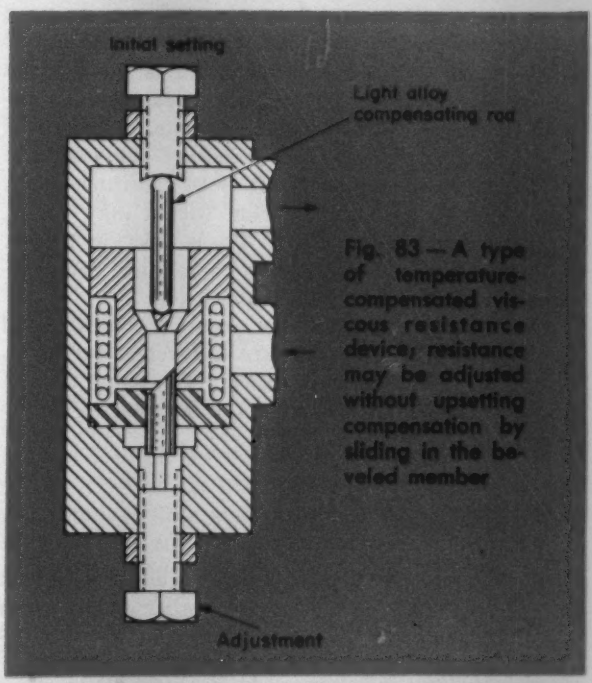


Fig. 83—A type of temperature-compensated viscous resistance device; resistance may be adjusted without upsetting compensation by sliding in the beveled member

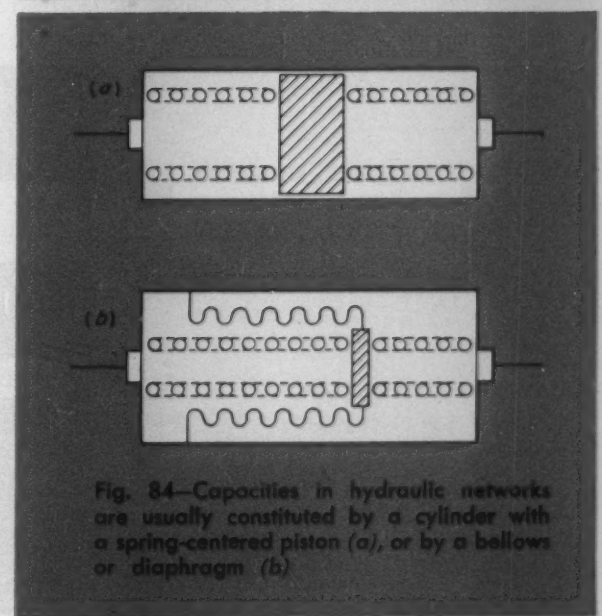


Fig. 84—Capacities in hydraulic networks are usually constituted by a cylinder with a spring-centered piston (*a*), or by a bellows or diaphragm (*b*)

wanted. Capacities in hydraulic networks are usually constituted by a cylinder with a spring-centered piston, or by a bellows or diaphragm, in which case the bellows or diaphragm itself provides at least some of the required spring rate. Examples are shown in *Fig.* 84. Let A be the effective area, which in the case of a bellows or diaphragm is numerically the same as the volume required to produce unit deflection. If h is the spring rate and p the applied pressure difference, the load is pA and the displaced volume pA^2/h. The capacity is therefore $C = A^2/h$.

Neither bellows nor diaphragms are able to withstand large pressure differences, 200 psi, or even less for the larger sizes being the usual limit; of course even if the supply pressure is quite large the pressure *difference* across a capacity may remain moderate. In the case of pistons, seals should be avoided as they cause excessive friction, and sealing must then depend on close clearance only. Even then appreciable friction forces may occur, as they do in slide valves. These friction forces, and some methods of avoiding them, have been discussed in connection with valve loads.

The transfer function of a capacity, relating the flow q into it to the pressure difference across it, is $p/q = 1/Cs$, which is exactly the same as the voltage-current relationship for an electrical capacity.

Mechanical Networks

One example of a mechanical network is shown in *Fig.* 85. If f is the spring rate, A the cross section area of the dashpot, F the applied force, y_i and y_o the displacements at input and output end respectively, R the resistance (assumed linear) of the dashpot, the equations of motion will give $F = f(1 + t_1 s)\ (y_i - y_o)$ where $t_1 = A^2R/f$.

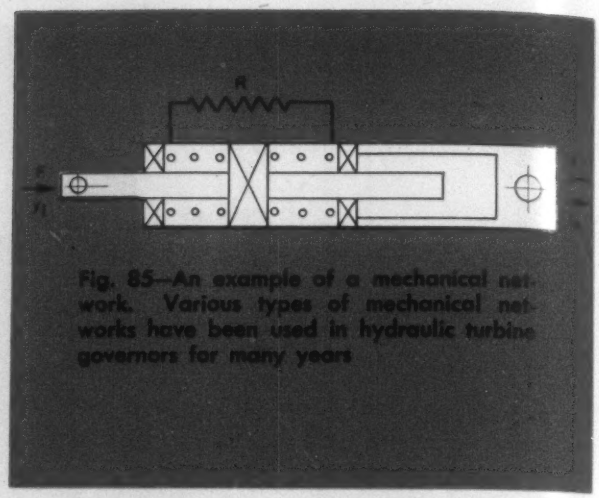


Fig. 85—An example of a mechanical network. Various types of mechanical networks have been used in hydraulic turbine governors for many years

If the output displacement is very small as compared to the input displacement, the force F gengenerated by an input displacement y_i is $F \approx f(1 + t_1 s)\ y_i$ which is a phase advance type characteristic. In this case the input is a displacement and the output a force; the latter can be applied for instance to a seating valve in a potentiometer arrangement, thus creating a pressure proportional to F.

Mechanical networks of various types have been used in hydraulic turbine governors for many years. Another highly successful application is in the British Admiralty's "creeping relay", which is illustrated in diagrammatic from in *Fig.* 86.

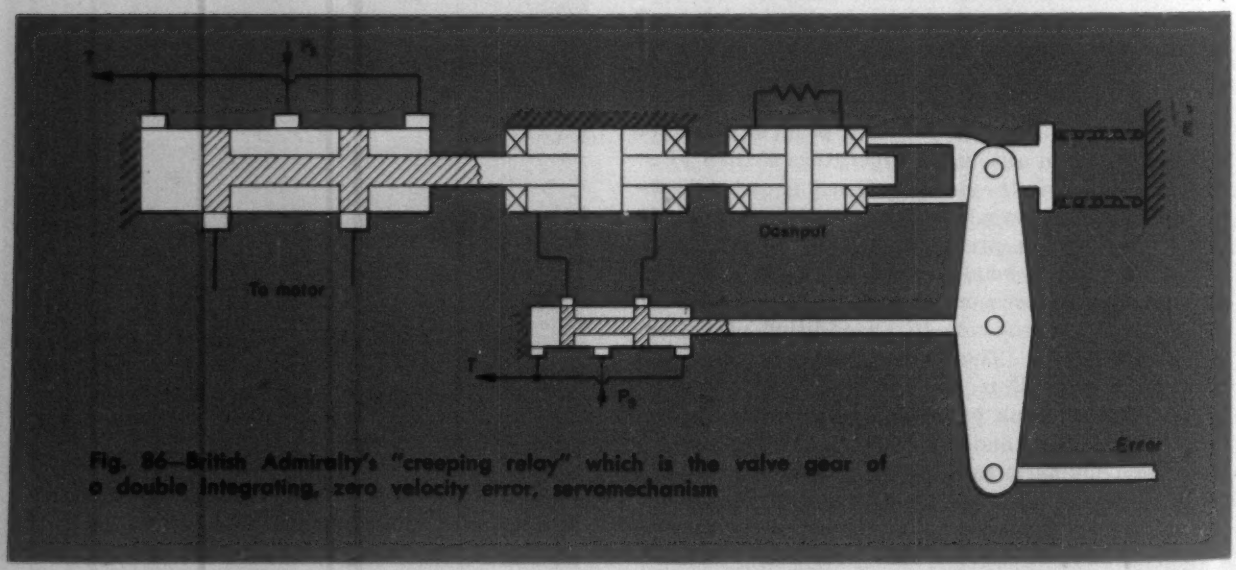


Fig. 86—British Admiralty's "creeping relay" which is the valve gear of a double integrating, zero velocity error, servomechanism

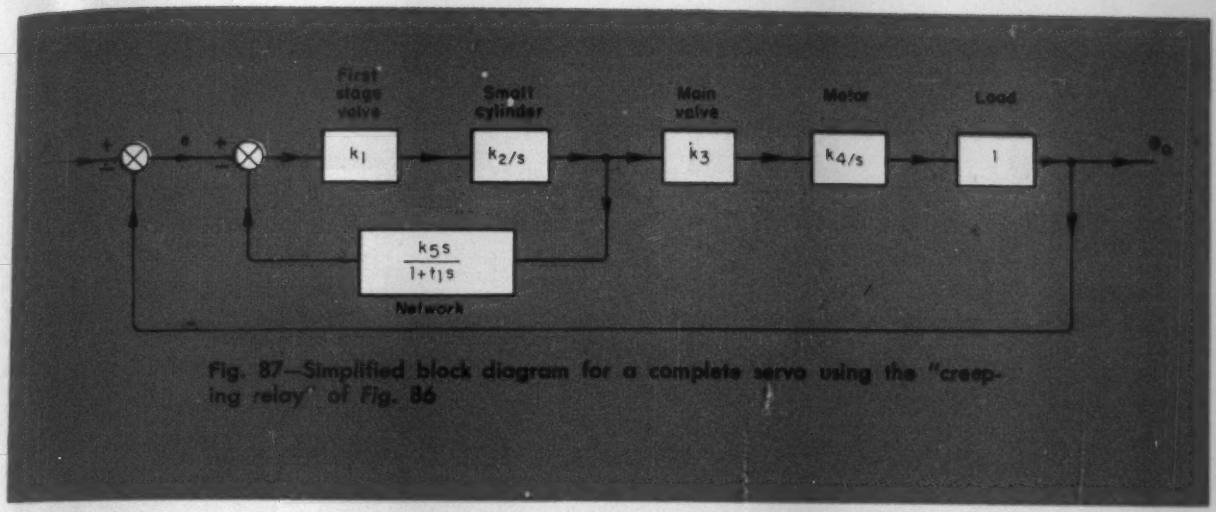


Fig. 87—Simplified block diagram for a complete servo using the "creeping relay" of *Fig.* 86

This is the valve gear of a double integrating—zero velocity error—servomechanism widely used in British naval gunnery. A simplified block diagram for a complete servo using this device is shown in *Fig.* 87. For the present discussion it is sufficient to assume that the effect of load even in the output stage may be neglected, in which case the transfer functions of the various components are as shown in *Fig.* 87, and the loop transfer function for the whole servo is of the type

$$\frac{K}{s^2}\left(\frac{1+t_1 s}{1+t_2 s}\right) \text{ with } t_1 > t_2$$

Without the network the transfer function would be merely K/s^2 which expresses double integration, and which would give an unstable system. The effect of the network is to give phase advance and thus achieve stability. The zero velocity error characteristic may be deduced quite easily from *Fig.* 86 even without resort to mathematics: under equilibrium conditions the dashpot is stationary and the spring force therefore zero. There is then no feedback to the first stage valve; the latter can therefore be closed, implying zero error, while the second stage valve is open by a fixed amount, and the load is therefore moving at constant speed.

In a mechanical network the dashpot forms a self-contained hydraulic system, which must be kept filled despite leakage and thermal contraction. There is some compensating advantage in that, since the volume of liquid involved is quite small, it would be practicable to use some silicone fluid having quite small variation of viscosity with temperature, which for any other application would usually be regarded as prohibitively expensive.

A whole collection of mechanical networks, together with their transfer functions, is listed by Coombes[a,b] who also gives examples of their application in some rather complex and elaborate gunnery servos.

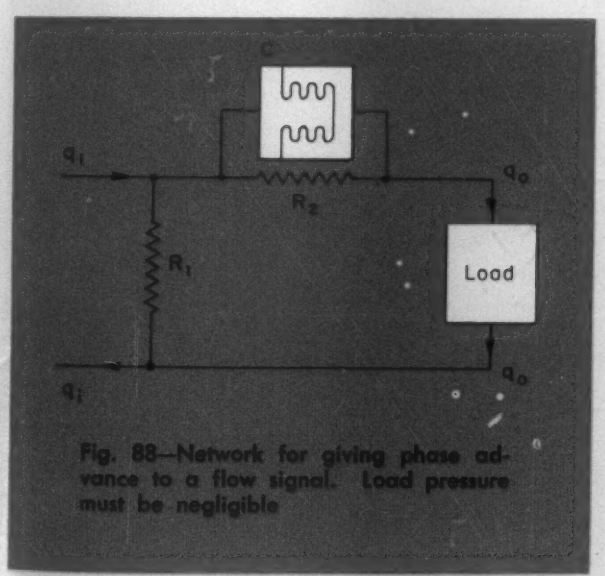


Fig. 88—Network for giving phase advance to a flow signal. Load pressure must be negligible

▶ Circuit Networks

Hydraulic or pneumatic passive networks exactly analogous to their electrical counterparts are feasible. Networks for "processing" pressure signals would be the exact counterparts of electric networks used for processing potential, examples of which have been shown in *Figs.* 10 and 13. In hydraulic servos the signal is more often a flow than a pressure, and a network for processing flow would be the analog of an electric network for processing current. A network for giving phase advance to a flow signal is shown in *Fig.* 88, which is the potential phase advance network of *Fig.* 10 reversed. While in processing potential or pressure, the output impedance should be infinite, in processing current or flow the output impedance should be zero. Therefore, in the case of *Fig.* 88

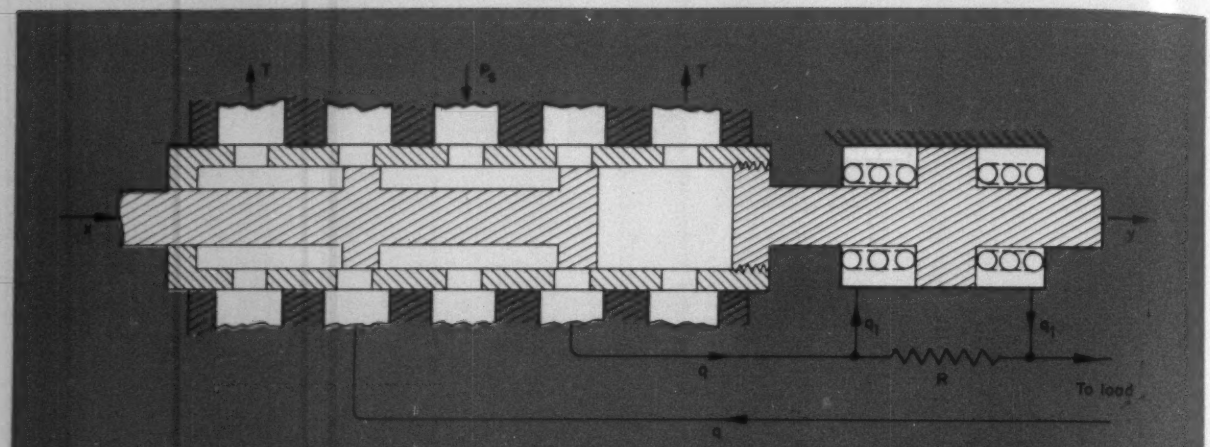


Fig. 89—Feedback network for phase advance; this network makes double use of capacity elements which are caused to function as miniature actuators

the load pressure must be negligible.

For these and other reasons, passive networks of the type just illustrated are very seldom, if ever, used in pneumatic or hydraulic servos. Much better results can be obtained by networks used in conjunction with subsidiary feedback loops. In these, it is usual to make a double use of capacity elements, which are caused to function as miniature actuators. An example of a phase advance system of this type is shown in *Fig.* 89. Let x be the input signal, y the feedback signal—the travel of the capacity element—the area of which is A. Let q be the flow out of the valve and q_1 the flow into the capacity. Then $q = k\ (x - y)$, and $y = q_1/As$. The pressure drop across the resistance R is $p = R(q - q_1) = q_1/Cs$. These equations give the transfer function of the valve and network, which is

$$\frac{q}{x} = \alpha K \left(\frac{1 + t_1 s}{1 + \alpha t_1 s} \right) \text{ with } t_1 = RC,\ \alpha = \frac{A}{A + kCR}$$

Feedback networks of various types are in widespread use in pneumatic process control equipment. Here the basic apparatus is usually

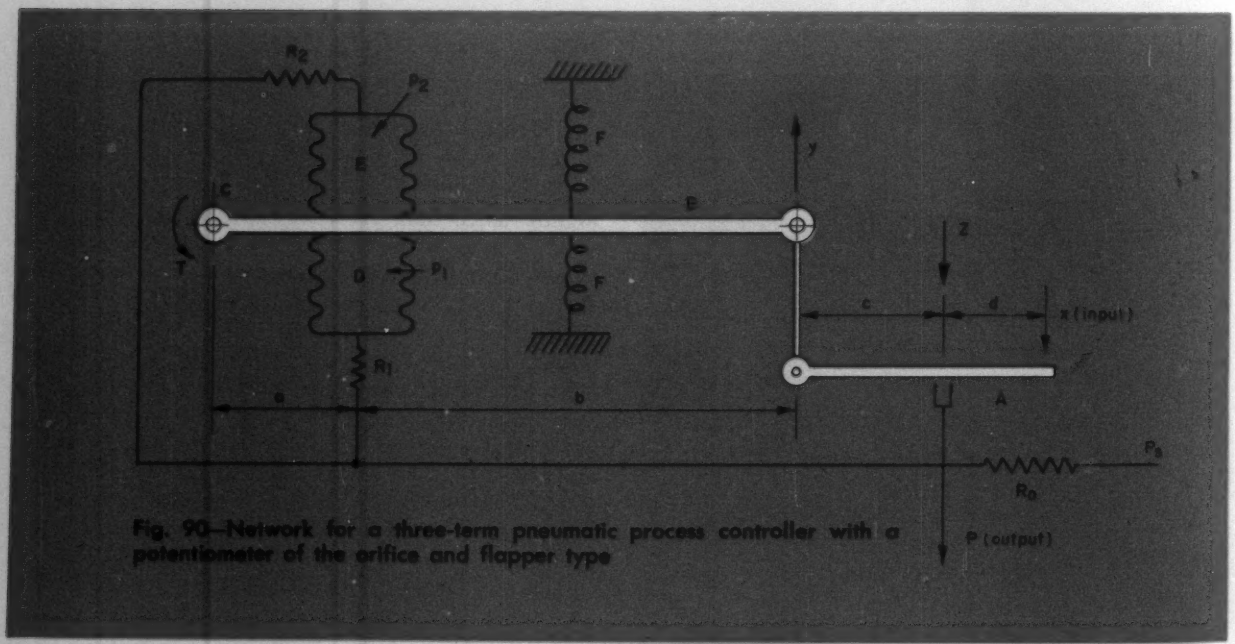


Fig. 90—Network for a three-term pneumatic process controller with a potentiometer of the orifice and flapper type

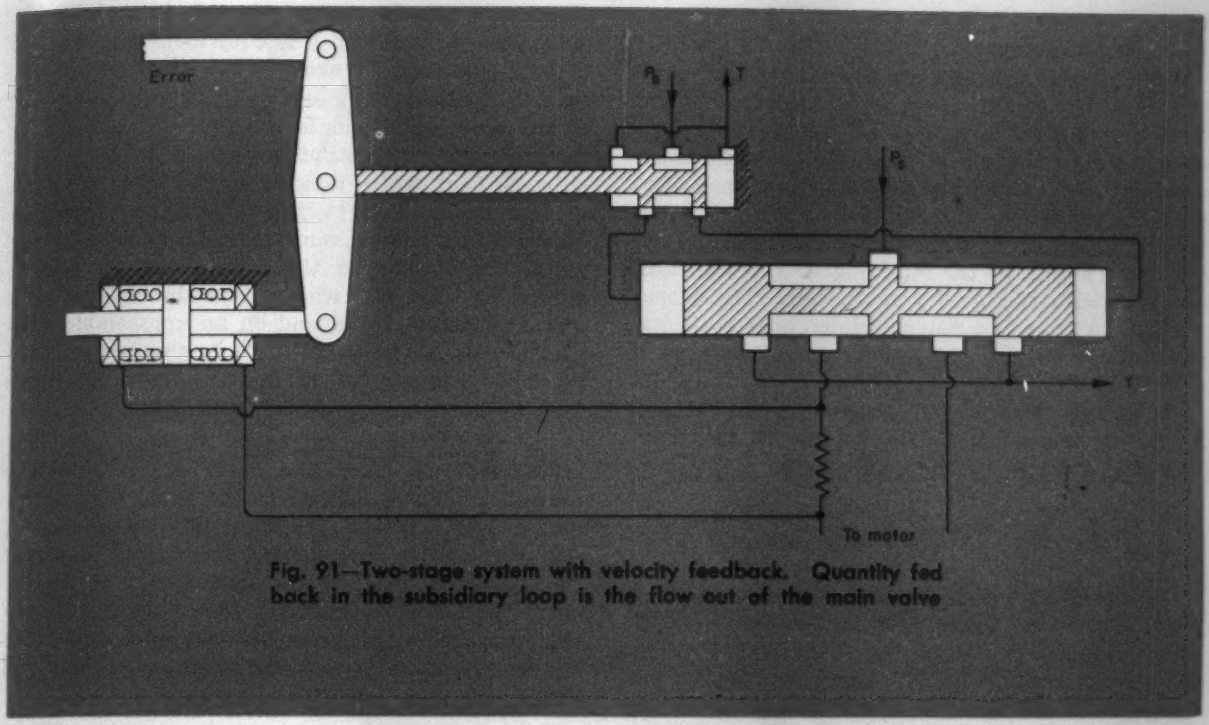


Fig. 91—Two-stage system with velocity feedback. Quantity fed back in the subsidiary loop is the flow out of the main valve

some potentiometer arrangement, with a motor of the spring-loaded diaphragm type. As shown in an earlier section, the transfer function of this combination is of the type $K/1 + t_o s$; the time constant t_o is usually very small in relation to the other time constants involved, and may be neglected. The transfer function is then simply a constant K. This would give what is known in process control theory as "proportional control", which is quite suitable for some plants, but allows some "load droop". As explained in part 1, load droop is analogous to position error in servomechanisms. To eliminate this use is made of "integral control", which means a transfer function of the type K/s. For greater stability, a phase advance term may be added, giving what is known as "integral plus proportional control", the transfer function then being written

$$K\left(1 + \frac{1}{t_i s}\right)$$

where t_i is known as the integral time constant. In difficult cases, particularly for temperature control, double phase advance is used, giving what is known as "proportional plus integral plus derivative" or "three term" control. The transfer function then is usually written as

$$K\left(1 + \frac{1}{t_i s} + t_d s\right)$$

where t_d is called the derivative time constant. Occasionally use is also made of "proportional plus derivative" control, with a transfer function

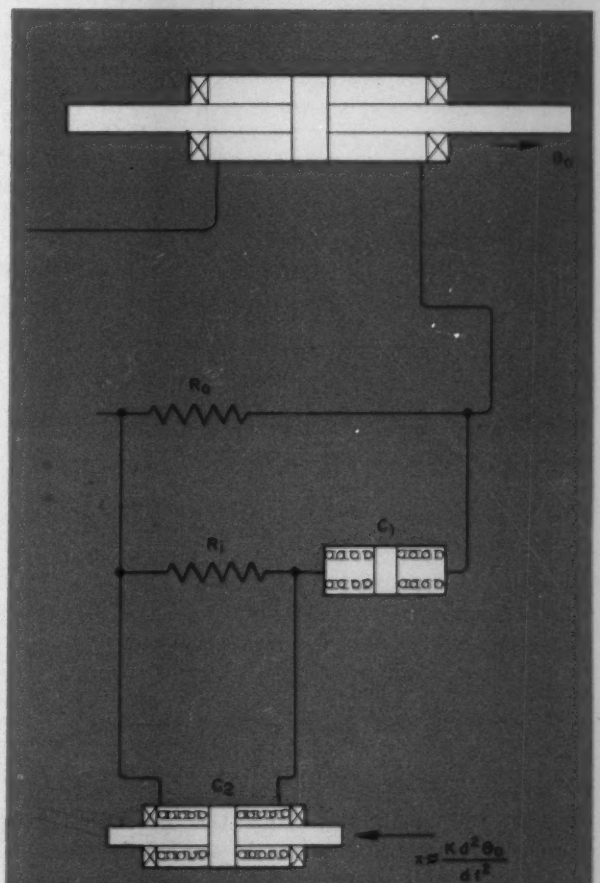


Fig. 92—Network for acceleration feedback

of the type $K(1 + t_d s)$. The constants K, t_i, t_d must be adjustable.

Nothing better than reasonable approximations to these transfer functions is sought. In fact, "pure" derivative terms are not physically realizable . Various networks[6d] are used to obtain these characteristics. One example for a three-term controller is shown in *Fig.* 90, and consists of a potentiometer of the orifice and flapper type, the flapper being moved by the input signal x at the right and the feedback signal y at the left. The output pressure p from the potentiometer goes to a diaphragm motor, producing a movement proportional to p.

Assume that the output pressure is proportional to the movement z of the flapper at the point opposite orifice. Then

$$v = Kz = \frac{K(cx - dy)}{c + d}$$

The feedback signal is produced by a lever B pivoted at C, and acted upon by bellows D and E, having capacities C_1 and C_2. The lever B is restrained by springs F, which exert a torque g per radian deflection of the lever. The bellows are fed through resistances R_1 and R_2. Let p_1 and p_2 be the pressures in D and E respectively. These pressures are subject only to relatively small variations from their average values, and under these conditions it is easily shown that $p_1 = p/(1 + t_1 s)$ and $p_2 = p/(1 + t_2 s)$ where $t_1 = R_1 C_1$; $t_2 = R_2 C_2$. The torque exerted about the pivot C is $T = Aa(p_1 - p_2) = gy/b$. All these equations together give

$$p\left[\frac{1}{K} + \frac{bAa}{g}\left(\frac{s(t_2 - t_1)}{(1 + t_1 s)(1 + t_2 s)}\right)\right] = \frac{cx}{c + d}$$

$$Put\ m = \frac{c}{(c + d)}\left[\frac{g(t_2 + t_1)}{bAa(t_2 - t_1)}\right]$$

If K is very large, $1/K$ may be neglected, and the equation becomes approximately

$$\frac{p}{x} \approx m\left(1 + \frac{1}{(t_1 + t_2)s} + \frac{t_1 t_2 s}{t_1 + t_2}\right)$$

which is the required "three term" characteristic. Further examples of networks for similar purposes are given by Farrington[6c] and Broadhurst[6d].

Velocity and Acceleration Feedback

In hydraulic servos a rough measure of output velocity is obtainable from the pressure drop across a resistance inserted in one of the lines to the motor. This pressure difference can be applied to a small spring-centered cylinder, which will then move by an amount proportional to output velocity. The signal obtained is subject to errors due to compressibility and leakage in the cylinder, and is therefore likely to be useless for the purpose of combating instability due to these effects.

One possible application of this kind of velocity feedback is shown in *Fig.* 91; this is a two-stage valve system more or less equivalent to those of *Figs.* 77, 78, and 79 except that the quantity fed back in the subsidiary loop is not the displacement of the main valve but is the flow out of it. The result is that the output velocity is highly insensitive to load, which may be a good ideal at which to aim but is likely to cause difficulties with stability. This type of velocity feedback is only superficially similar to the phase advance system shown in *Fig.* 89, which depends on feedback around a single valve, and on an appreciable time constant in the feedback loop. In the present case the time constant RC of the resistance and feedback cylinder should be as low as possible.

Fig. 92 shows an extension of the above idea, giving a rough acceleration signal for feedback purposes. This is subject to the same limitations, and indeed involves additional difficulties.

If the load is pure inertia, the output acceleration is proportional to the load pressure. An accurate acceleration feedback signal is then obtainable merely by applying the pressure difference across the motor to a very small spring-centered cylinder.

Quite accurate output velocity signals may be obtained from an eddy current device attached to the motor or load; this may consist, for instance, of a copper disk rotating with the load, and located inside a magnetized stator restrained by springs. The movement of the stator will then be proportional to load velocity. In practice such devices are feasible only with continuous rotary motors, and must be located at the high speed end of the reduction gearing. Devices based on viscous drag instead of eddy current drag should be equally feasible, and more powerful, but of course are highly sensitive to temperature.

Concluding Remarks

Fluid pressure servomechanisms are of quite respectable antiquity, but in recent years immense progress has been made in methods of analysis, in techniques for improving performance, and in the construction of individual components. Although much of this work has been in connection with applications for military purposes, a gratifying amount of information has been published, and there is little doubt that much more will be forthcoming as research and development proceed.

Several of the techniques and methods of analysis described in this series are quite new and have only received limited application at the time of writing. It is to be hoped that more experimental research work will be done to investigate their effectiveness.

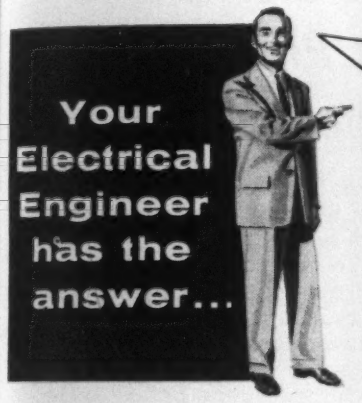
REFERENCES

6b, 6c, 6d, 7e—See References—Part 2—Nov. AUTOMATION

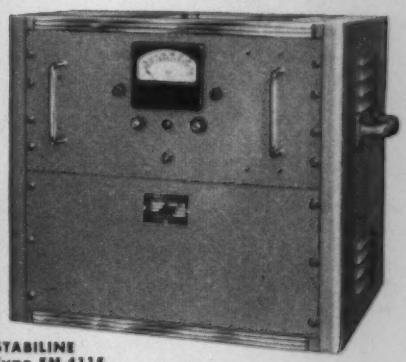
17. C.I.O.S. Report—"Variable Speed Drive for 5.5 cm Flak"; XXXII-63, 1945

V.V.T.*

the "Phantom Saboteur" of Automation can cause 101 production troubles... rejects . . . without your knowing it!

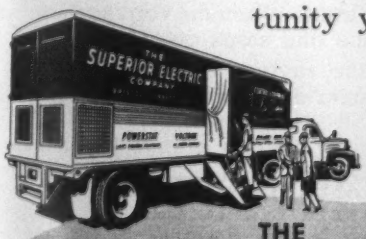


* "Varying Voltage Trouble plays hob with timers, solenoids, and electronic gear in production and inspection departments. A Stabiline Automatic Voltage Regulator prevents this 'sabotage'."



STABILINE
Type EM 4115
Superior Electric offers a complete line of automatic voltage regulators. Send for Bulletin S351.

• Automatic machines and processes . . . inspection department equipment can go "haywire" every time your voltage varies — even within so-called "allowable limits". Given the opportunity your plant Electrical Engineer can spot V.V.T. and help you cure many production headaches you now consider to be "routine trouble" that you have to live with. When he recommends a Stabiline automatic voltage regulator you can be sure *these* troubles are under control.



See Superior Electric's Mobile Display when it visits your area.

THE SUPERIOR ELECTRIC COMPANY

BRISTOL, CONNECTICUT

Manufacturers of: POWERSTAT Variable Transformers • STABILINE Automatic Voltage Regulators • VOLTBOX A-C Power Supplies LUXTROL Light Control Equipment • VARICELL D-C Power Supplies Superior 5-WAY Binding Posts

THE SUPERIOR ELECTRIC COMPANY, 803 Reynolds Ave., Bristol, Conn.

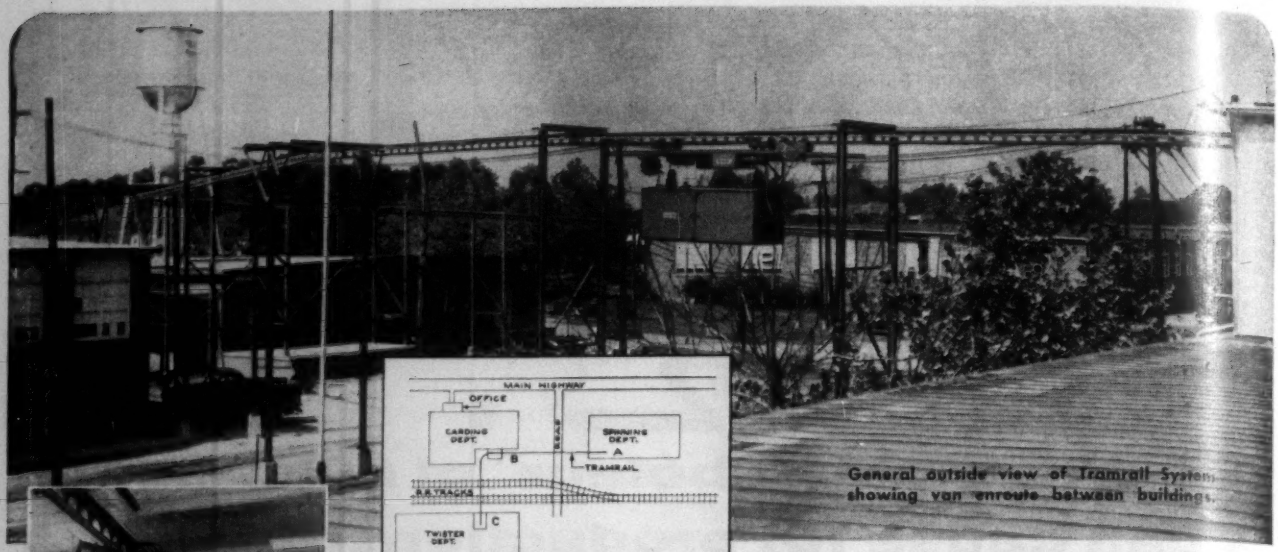
Please send me a copy of your STABILINE Bulletin S351.

Name.....

Company Name.....

Company Address.....

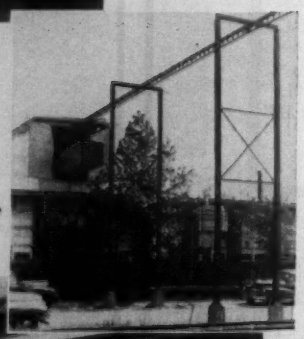
City.....Zone.....State.....



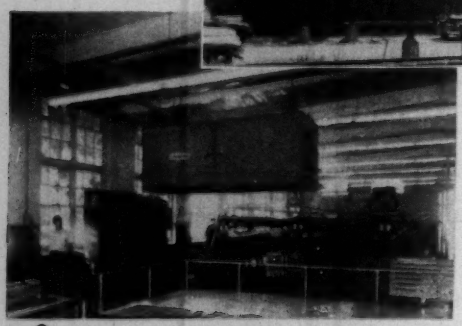
General outside view of Tramrail System showing van enroute between buildings.

Integrates Three Separate Mills *Into One Efficient Plant* With Automatic Handling System

Loading four truck loads of spools and bobbins into van in Spinning Department.



Van entering penthouse on roof of Twister Department.



Starting load on way by depressing wall button.

In South Gastonia, N. C., Textiles, Inc. took over three mills, now known as Pinkney Mills, which are separated by a street and a railroad and which had been operated in the past as wholly separate mills. To integrate the operations, it installed a Cleveland Tramrail automatic dispatch system to carry materials between the buildings. This made it possible to concentrate on carding work in one building, spinning in another, and twisting in the third. Roving is dispatched from the Carding Department to the Spinning Department, and bobbins, spools and cheeses of yarn made in the Spinning Department are dispatched to the Twisting Department over the Tramrail system.

The handling work requires no extra help because it can be done quickly by people in the three buildings along with their regular work. All that is necessary is to push trucks in and out of the Tramrail van, close the van doors and press a button which starts the unit on its way.

Rain or shine, the system works without complaint. It connects with floors at different elevations and travels up and down grades over street and railroad. When the van reaches its destination, it lowers at once and stops automatically.

Management advises that the savings effected by use of the automatic dispatch system will pay for the equipment within a short period.

GET THIS BOOK!

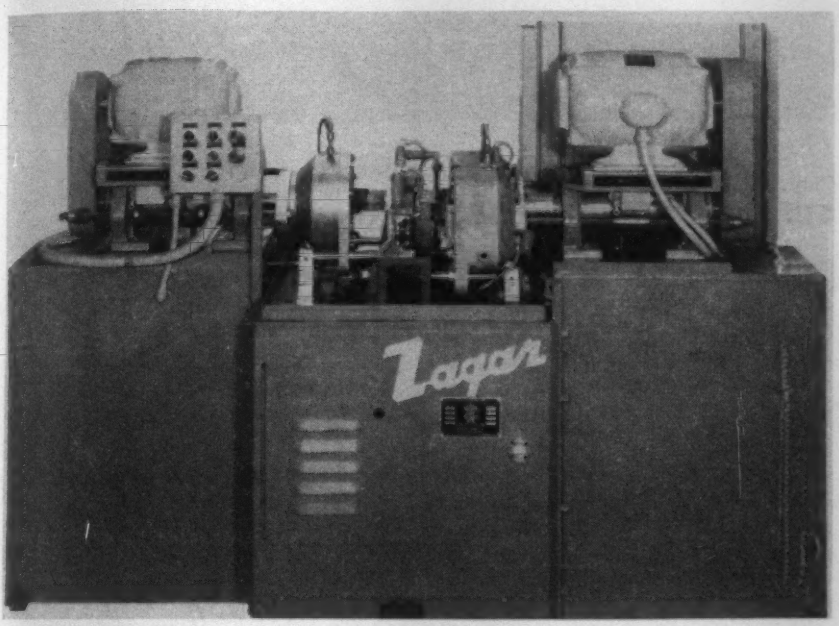
BOOKLET No. 2008. Packed with valuable information. Profusely illustrated. Write for free copy

CLEVELAND TRAMRAIL DIVISION
THE CLEVELAND CRANE & ENGINEERING CO.
1377 East 287th Street Wickliffe, Ohio

CLEVELAND TRAMRAIL
OVERHEAD MATERIALS HANDLING EQUIPMENT

AUTOMATION NEW EQUIPMENT

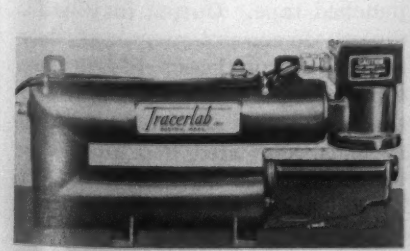
Machines and plant equipment designed for more automatic operation



PRODUCTION DRILLING MACHINE

Horizontal drilling machine drills and countersinks 100 holes per hour in a rectangular rod. Machine is interlocked electrically for automatic operation, and has two hydraulic feeder units and two gearless drill heads. Twenty holes are drilled from one side in a rectangular rod of extruded bar stock at the first station, and the work is indexed manually to countersink 20 holes from both sides at the second station. The bar is indexed progressively until a 10-ft piece is completely drilled. An automatic punch press then cuts the bar forming sprags for an automatic transmission assembly. **Zagar Tool, Inc.,** 24000 Lakeland Blvd., Cleveland 23, O.

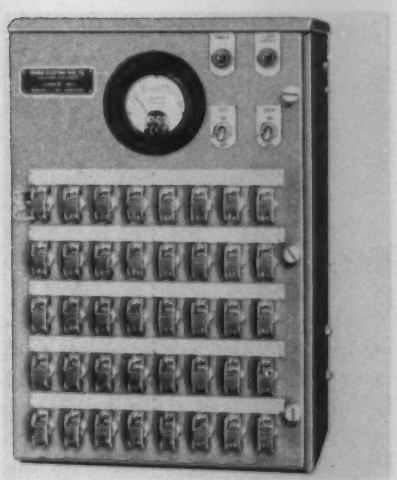
Circle No. **1** *on Reply Card*



LIGHT MATERIAL GAGE

New beta gages for controlling sheet weight of light, critical materials utilize a radioactive source of Cesium-137. This isotope has low energy beta rays which are suited to gaging of light materials, and has a half life of 33 years. Older gages used radiothallium with a half life of 2.7 years. Instrument's full scale sensitivity is equivalent to a weight change of only 12 lb per 3000 sq ft of paper, or to a thickness change of only 1 mil of a plastic film such as saran. Gage is available with a variety of throat depths, and with all-angle scanning mounts which provide across-the-sheet weight profiles. **Tracerlab Inc.,** 130 High St., Boston 10, Mass.

Circle No. **2** *on Reply Card*

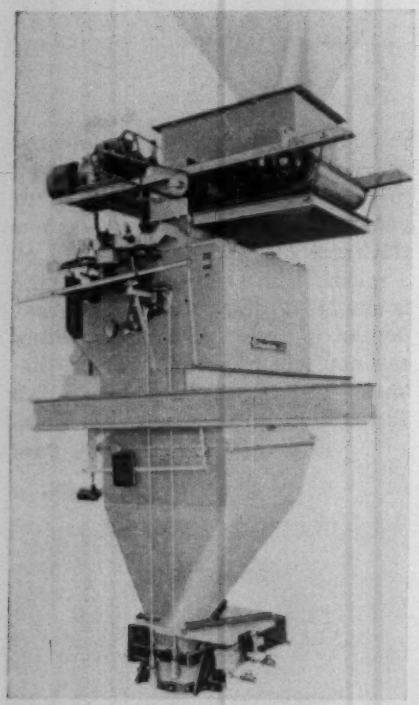


TEMPERATURE MONITOR

Originally designed for military use, automatic bearing-temperature monitoring system is now available for industrial use. System continuously monitors bearing temperatures and actuates alarms when bearing temperatures rise above safe limits. Monitor consists of thermocouples installed at points where temperature is to be checked, and a bank of magnetic amplifiers which magnify the feeble electrical output of the sensitive

thermocouple to a level sufficient to actuate the alarm system. Amplifiers employ no moving parts or filaments. Standard units warn by an audible signal and lamp indication when temperature reaches 500 F, although alarm point can be adjusted to meet individual applications. **Bogue Electric Mfg. Co.,** Dept. LS-1, 52 Iowa Ave., Paterson 3, N. J.

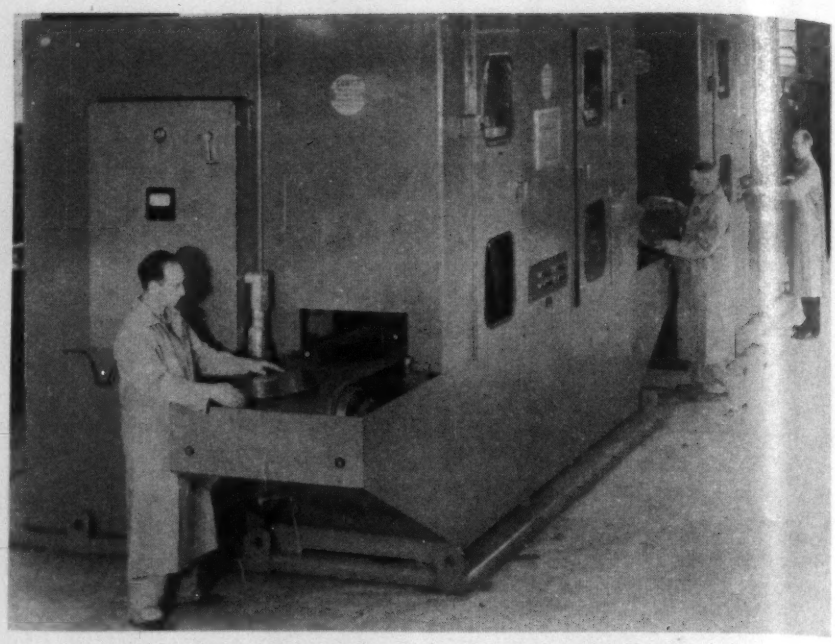
Circle No. **3** *on Reply Card*



BAGGING SCALE

Synchronized belt feeder and pneumatic inlet gate assist have been added to standard mechanically operated bagging scale to permit faster and more varied operation. Unit weighs lumpy materials and will handle weights from 25 to 100 lb. Among typical products handled are chemicals, grains, feeds, food products, fertilizers, rock products and ceramic materials. Operation of belt feeder is synchronized with operation of scale. When inlet gate of the scale closes, the feeder drive motor stops; after the scale discharges, the inlet gate opens and the motor starts again. Feeder is equipped with a built in brake to prevent coasting and a ¾ hp drive motor. **Richardson Scale Co.,** Van Houten Ave., Clifton, N. J.

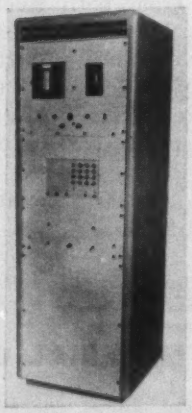
Circle No. **4** *on Reply Card*



SURFACE GRINDING MACHINE

Thirty-five ton surface grinding machine has been designed for use in automotive industry for prefinishing steel blanks prior to forming. Machine is said to substantially reduce manual polishing and further finishing operations prior to plating. Four head abrasive belt surface grinder uses finer grinding belts. Blanks enter machine on a neoprene conveyor which permits grinding of small blanks as well as large. Rubber hold-down rolls and powerful permanent magnets used at point of grinding prevent slipping of blanks. Machine is designed for dry operation as well as wet abrasive grinding with cutting oil or water. Pushbutton control allows quick adjustments of grinding heads for various thicknesses of stock. Abrasive belts are provided with automatic tensioning and tracking. Conveyor speed is 15 to 60 fpm. **Curtis Machine Corp.,** Jamestown, N. Y.

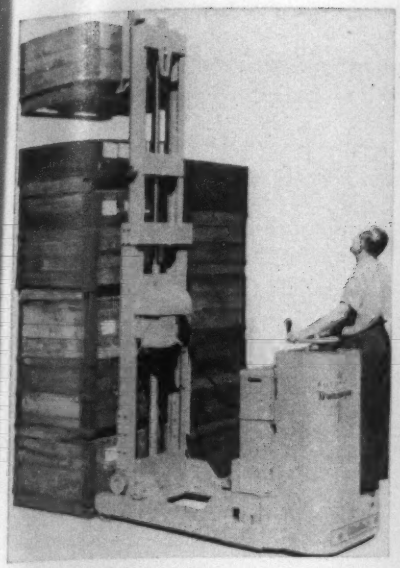
Circle No. **5** *on Reply Card*



PRESSURE READOUT

Multiple pressure readout system simultaneously samples up to 200 pressures with accuracy of approximately 1 part in 2000 and digitally records them. Machine, which is called Automatic Press-I-Cell Logger, is designed for use in aircraft wind tunnels, automotive and aircraft engine test facilities, marine model basins, and other facilities in which large numbers of pressures must be measured and recorded simultaneously with high accuracy. Machine automatically converts pressure magnitudes into digital form for recording as a typewritten column log and as a punched tape. Output may be fed directly to computers or card punch equipment without intermediate tape storage of data when typewritten log is not required. Readout cycle is completed in a little over 60 seconds. **Fischer & Porter Co.,** 269 Jacksonville Rd., Hatboro, Pa.

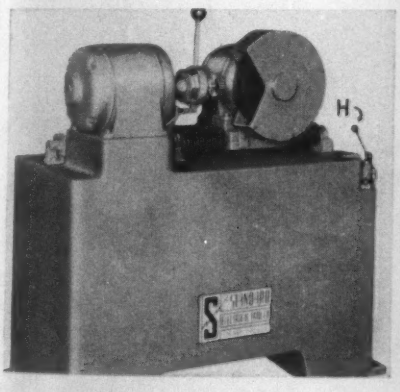
Circle No. **6** *on Reply Card*



ELECTRIC STACKER

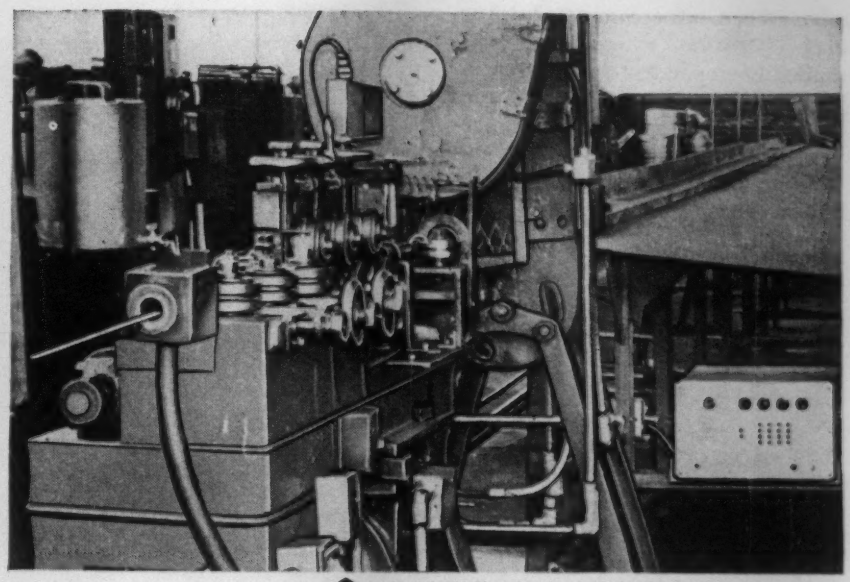
Rider-operated electric stacker features both fork and mast assembly which extend and retract within the track frame. Designated as the ESRT Transveyor, truck is said to have 50 per cent greater reach and ⅓ greater load capacity than previous models. Transveyor is designed for tiering and detiering in aisles as narrow as 6½-ft, and can carry 4000 lb with a 36-inch pallet. Fork and mast assembly extends and retracts 36 inches. **Automatic Transportation Co.,** 149 W. 87th St., Chicago 21, Ill.

Circle No. **7** *on Reply Card*



BRUSHING LATHE

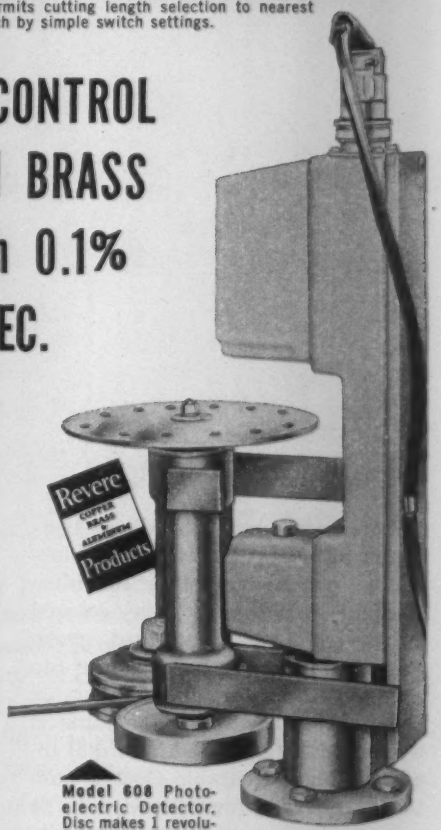
Designed for deburring both face edges of gear or sprocket teeth simultaneously, automatic cycle high production brushing lathe is suitable for work from 3 to 10-inch diameters. Lathe has two 12-inch diameter brushes spaced for contact with opposite radii of other



Model 144 Predetermined Electronic Counter permits cutting length selection to nearest inch by simple switch settings.

POTTER COUNTERS CONTROL REVERE COPPER and BRASS TUBE SHEARING with 0.1% ACCURACY AT 100"/SEC.

Revere Copper and Brass uses Potter counting equipment to automatically control tube shearing into precise, pre-selected lengths. The photoelectric detector generates a count impulse for each incremental length, and the predetermined electronic counter actuates the shear mechanism at the preset count.



Model 608 Photoelectric Detector. Disc makes 1 revolution per foot of tube travel. 12 holes provide counting in inches. Resolution of measurement can be increased if desired.

Automation need not be complicated or expensive. Many users install Potter systems without interrupting production. Exclusive circuits assure long-lasting, trouble-free operation.

Send full details of your packaging or control problems today. Our engineers will be pleased to submit a detailed proposal. No obligation, of course.

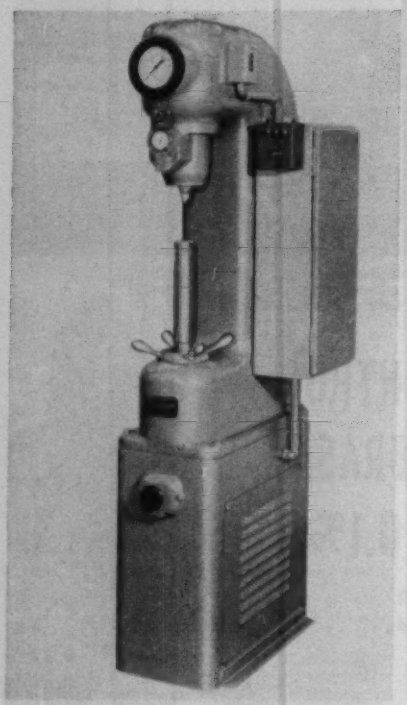
Potter POTTER INSTRUMENT COMPANY, INC.

115 Cutter Mill Road, Great Neck, N. Y.

See us at the I.R.E. Show—Booth 346

gear. When lathe completes deburring operation, wheel head automatically traverses to starting position, with wheel and work motors instantly stopping. Each cycle reverses wire brush rotation for more efficient brush life. **Standard Electrical Tool Co.,** 2550 River Rd., Cincinnati 4, O.

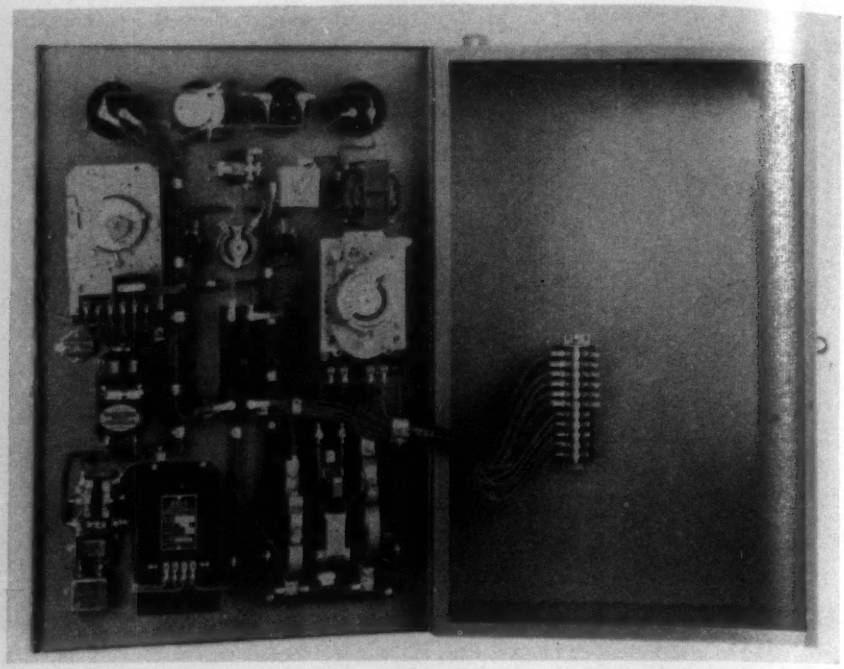
Circle No. **8** *on Reply Card*



HARDNESS TESTER

Automatic brinell hardness testing is now possible through color-glance hardness testing machine. Machine employs three colored lights—yellow for too hard, green for within range, and red for too soft—to indicate acceptability or rejection of test piece. Machine is hydraulically operated, and dial indicator has adjustable electric contacts. In order for operation to be completely automatic, circuits which operate lights can be used to activate solenoid valves, switches or other electrical equipment which physically sort parts into the three categories. Additional material handling means must also be provided, with machine cycle to be started by limit switches. Models with 6 and 10-inch throat depths and 14-inch maximum vertical opening are available. **Steel City Testing Machines, Inc.,** 8817 Lyndon Ave., Detroit 38, Mich.

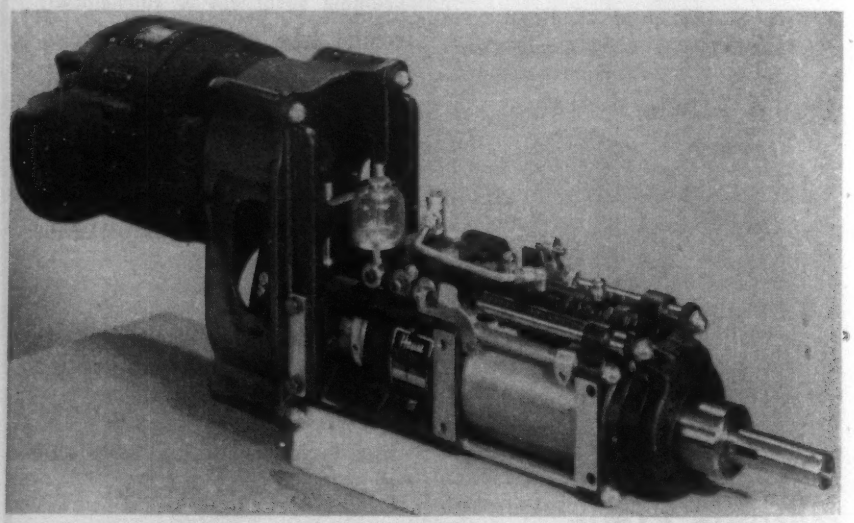
Circle No. **9** *on Reply Card*



AUTOMATIC STOP-START CONTROL PANEL

Designed for use in sequence operations, load transfer, machine tools, fuel flame control, textile machines and process equipment, compact automatic control panel cuts in an engine alternator during power failures or other emergencies. New circuit is said to have fewer working parts than previous models. Equipment can also be applied to warning panels, superheaters and microwave equipment. **Industrial Control Panel Co.,** 247 E. Illinois St., Chicago 11, Ill.

Circle No. **10** *on Reply Card*

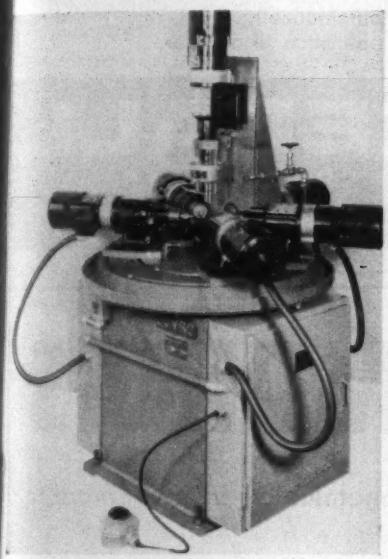


SELF CONTAINED DRILL UNIT

Air-hydraulic drill unit has a self-contained electric motor-pulley drive system designed to use either timing belt or V-belt drives for power transmission from the motor to the spindle. Among applications of unit are drilling, reaming, spot-facing, chamfering, tapping, threading and hollow milling. Interchanging of pulleys and motors provides speed variations from 300 to 10,000 rpm. Automatic hy-

draulic oil filling system maintains oil level in the hydraulic section of the drill, thereby reducing service requirements and increasing operating life. Advance and retract thrusts are developed by air pressure with single or multiple feed rates. Unit is capable of automatic, semiautomatic or manual cycling, skip drilling, back-feeding, manual jogging and positive stop with dwell operations. Built-in four-way air control valve can be actuated by built-in control poppets or by remote air or electrically operated valves. Unit operates on air supply pressures of 50 to 150 psi, and can maintain depth accuracies to 0.0005-in. **Hause Engineering,** Montpelier, O.

Circle No. **11** *on Reply Card*



DRILLING MACHINE

Both vertical and radial drilling are featured in new drilling machine which incorporates a vertical bracket. Bracket holds an automatic drilling unit with a multiple head, and enables machine to drill five radial holes and two vertical holes simultaneously. Drilling units may be arranged in variety of ways, allowing machine to take place of special units for many different drilling operations. Machine has range of 1/32 to 3/8-inch on drilling operations and 0-80 to 3/8-16 on tapping operations. **Govro-Nelson Co.,** 1931 Antoinette, Detroit 8, Mich.

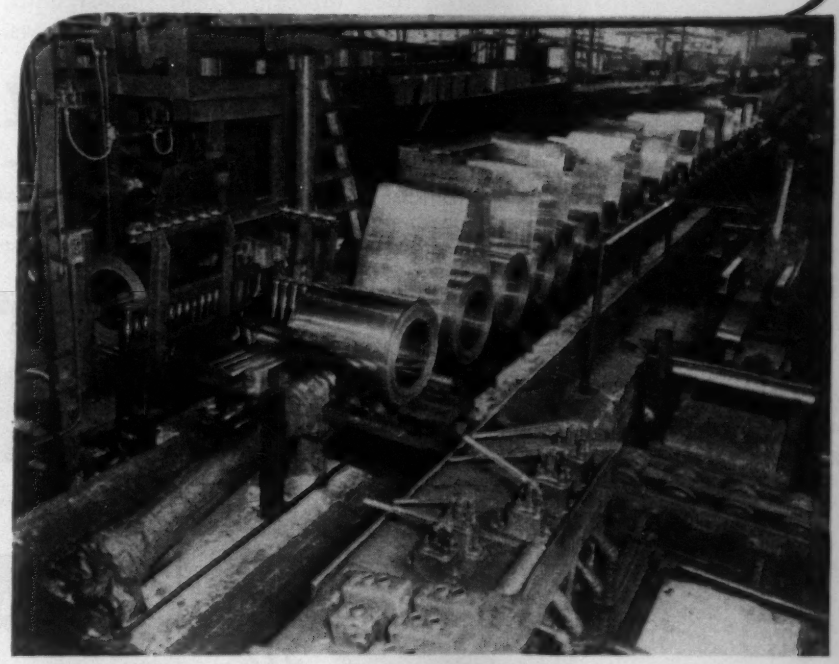
Circle No. **12** *on Reply Card*

Automation

WE'VE WORKED TOWARD IT

FOR 50 YEARS AND CALLED IT

CONTINUOUS FLOW



Typical Mathews conveyer system made up of power conveyers and special conveying machinery in modern brass mill.

Mathews conveyers have for 50 years been helping manufacturers progress toward automation by handling materials to and from processing machines with a minimum of manual effort. Today, in almost every industry in plants throughout the United States and Canada, Mathews mechanized handling is at work creating a smooth, continuous flow of materials.

For information, write to the Mathews field office or plant nearest you. Ask for Catalog 853-R.

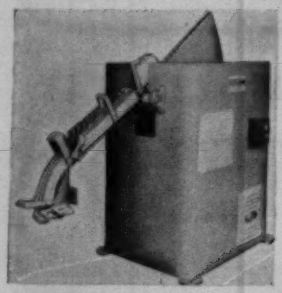
MATHEWS CONVEYER COMPANY

GENERAL OFFICES . . . . . ELLWOOD CITY, PENNSYLVANIA
PACIFIC COAST DIV. MATHEWS CONVEYER COMPANY WEST COAST. SAN CARLOS, CALIF.
CANADIAN DIVISION . . MATHEWS CONVEYER COMPANY, LTD. PORT HOPE, ONTARIO

Engineering Offices or Sales Agencies in Principal American and Canadian Cities

MATHEWS

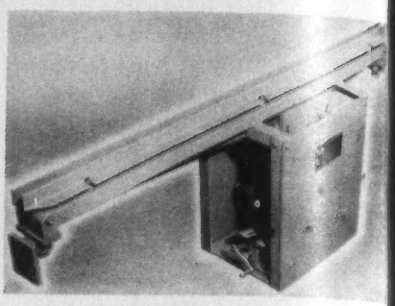
SPEED UP PRODUCTION WITH FEEDALL HIGH SPEED AUTOMATIC PARTS FEEDER—



Models 1500 and 2000

HOPPER-VIBRATORY-ROTARY-BLADE FEEDS

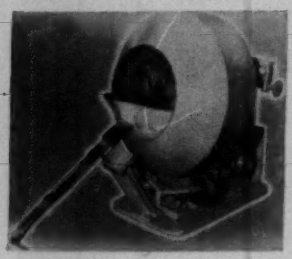
These fully automatic, self-driven units are designed to serve as auxiliary equipment for many types of production machines, such as centerless grinders, drilling machines, pipe and tube threaders and similar units, handling such small parts as bolts, screws, valves, piston pins, etc.



Transfer Conveyor

ELEVATING AND TRANSFER CONVEYORS

These units are a necessary part of the equipment used to convey parts automatically from one production operation to another.



Model 400

OUR EXPERIENCE WILL SAVE YOU MONEY—

As specialists in the design and manufacture of this type of equipment we can help you increase your production at lower unit handling costs through the use of these fully automatic units for automatic feeding to your machines.

Send samples, prints or production data for production estimates and related information.

FEEDALL
INCORPORATED
WILLOUGHBY, OHIO, U. S. A.

Write today for your free copy of this Technical Paper.

ask for data file **312**

Accuracy of Potentiometer Linearity Measurements

BY ROBERT MCDONALD & IRVING HOGAN
Research and Development Division
Helipot Corporation

Reprinted from TELE-TECH & ELECTRONIC INDUSTRIES

386

Helipot *first in precision potentiometers*

Helipot Corporation / South Pasadena, California
a division of BECKMAN INSTRUMENTS, INC.

STAMPINGS

Produced economically in our modern plant for:

AUTOMOTIVE, INDUSTRIAL EQUIPMENT, DOMESTIC APPLIANCE, AGRICULTURAL INDUSTRIES AND OTHERS; will boost your output at material savings.

Our production, engineering and toolroom facilities are geared to the volume usage of *your* industry.

Send us your inquiries

LANSING STAMPING COMPANY
1157 So. Pennsylvania
Lansing 2, Michigan
Serving Industry Since 1914

DUAL PURPOSE STACKER

is designed for operations where both a platform and forks are required, frequent and a fast lifting speed is needed. **Dept. R-69, Lewis-Shepard Products, Inc.,** Watertown, Mass.

Circle No. **13** *on Reply Card*

HOUSING PROCESSOR

mills, rough and semi-finish bores, faces, drills, and individual-lead-screw taps hydraulic power steering-gear housings at the rate of 96 per hour. **Buhr Machine Tool Co.,** Ann Arbor, Mich.

Circle No. **14** *on Reply Card*

DIGITAL CONTROL

supervisory system may be used in conjunction with any electrical transmission medium — telegraph circuits, telephone lines, VHF radio or microwave links, and is designed for remote measurement and control functions such as shaft positioning, on-off switching and proportional control. **Dept. 831, Pacific Div., Bendix Aviation Corp.,** 11600 Sherman Way, N. Hollywood, Calif.

Circle No. **15** *on Reply Card*

PALLETIZING MACHINE

designed for installation over conveyors, uses strips of adhesive to make a solid block of conveyed packages which will not shift or slip while in transit. **Potdevin Machine Co.,** 285 North St., Teterboro, N. J.

Circle No. **16** *on Reply Card*

AUTOMATIC BOILER

capable of producing 125 hp maximum rating, is designed for commercial and industrial heating and processing applications and is available with automatic controls for operating requirements. **Eclipse Fuel Engineering Co.,** 1002 Buchanan St., Rockford, Ill.

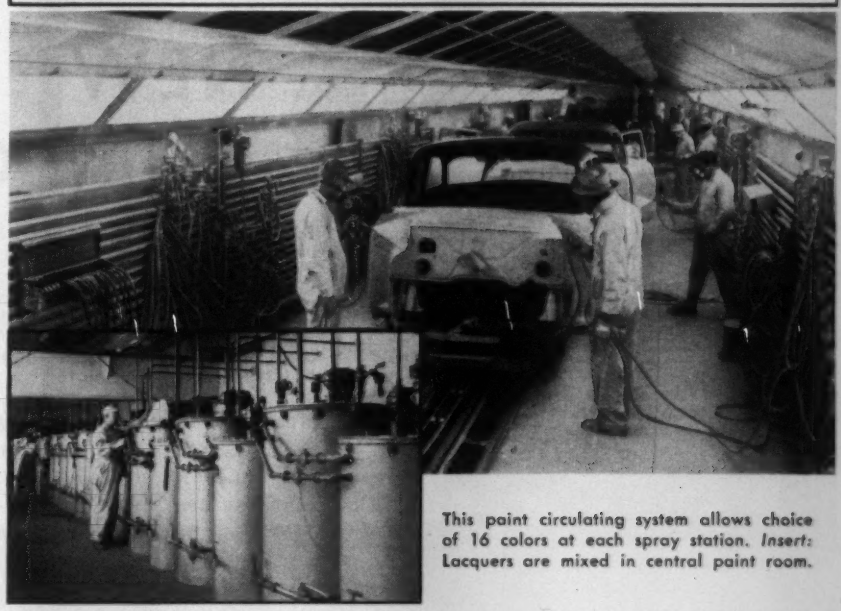
Circle No. **17** *on Reply Card*

ICE WARNING CONTROL

designed to sense jet engine icing and automatically control it. Electrically powered system can be modified to serve as a static velocity detector to safeguard radar antennae or any sensitive outdoor installation from ice formation. **Cook Electric Co.,** 2700 Southport Ave., Chicago, Ill.

Circle No. **18** *on Reply Card*

WHAT'S NEW in paint circulating systems



This paint circulating system allows choice of 16 colors at each spray station. *Insert:* Lacquers are mixed in central paint room.

Automatic paint circulating system guarantees Packard body parts will match

Here's how a closed-type Binks Paint Circulating System insures Packard's quality control

The lacquer sprayed by every paint spray gun in Packard's new Conner Avenue Plant in Detroit comes from a central source. This insures that parts painted in one end of the plant will perfectly match those finished in another section.

Paint for all operations is prepared under laboratory control in a fireproof paint mixing room which houses 22 dual tanks (each consisting of a separate mixing tank and supply tank), and 11 single units which combine a mixing and supply tank. Paint is mixed and maintained at 77° F. Color and viscosity are precisely controlled.

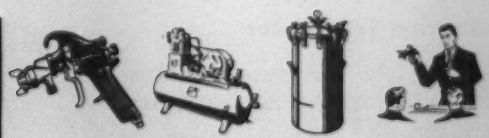
16 colors are piped from the tanks to all spray stations. In a matter of seconds, any sprayer can connect his gun to the line carrying the desired color. Uniform and measured paint delivery to each gun is assured by the use of Binks PM-103 Regulators. Atomizing air pressure is closely controlled by Binks AO-120 Oil and Water Extractors at each station.

The Packard paint circulating system allows 52 possible color combinations and is set up to apply 4 coats of lacquer in 2 or 3 tones. More than 400,000 gallons of lacquer are used each year.

Packard's choice of a Binks paint circulating system and Binks equipment is another example of how that company maintains "Complete Coordinated Cooperation" in all production.

If your production setup has 2 or more spray stations using in excess of 50 gallons of paint each day, it will pay you to investigate this type of installation. The more paint you use, the greater your savings. To learn of the many other advantages of a Binks Paint Circulating System, see your jobber or distributor, or write directly to:

Binks
EVERYTHING FOR SPRAY PAINTING



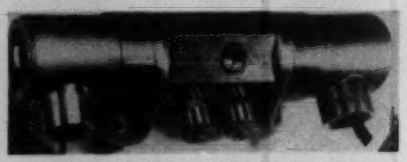
GUNS · COMPRESSORS · FLUID TANKS · FREE INSTRUCTION

BINKS MANUFACTURING COMPANY
3132-40 Carroll Avenue, Chicago 12, Ill.

REPRESENTATIVES IN PRINCIPAL U.S. & CANADIAN CITIES · SEE YOUR CLASSIFIED DIRECTORY

AUTOMATION NEW COMPONENTS

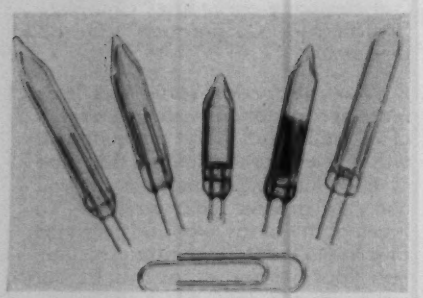
Parts, elements and devices designed for creating more automatic systems



Solenoid Air Valve

Solenoid valve-piloted air valve is capable of high actuation rates, operates on short electrical signal and has short reaction time. Two models, BVP1— single solenoid, spring return, and BVP2— double solenoid (shown above) available. Both models have ⅛, ¼, ⅜, or ½-inch NPT size ports, three or four-way, for dc voltage operation from 1.4 to 475, and for ac voltage from 3.6 to 750, in cycles of 25, 30, 40, 50, and 60. Valves are equipped with ½-inch NPT electrical conduit outlet. **Beckett-Harcum Co. Inc.**, Wayne Rd., Wilmington, O.

Circle No. **19** *on Reply Card*

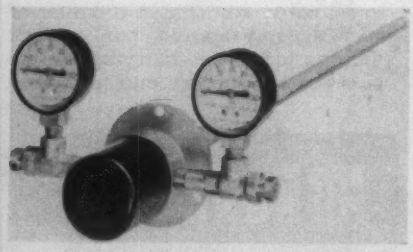


Ionization Transducer

Extremely accurate measurement of pressure, humidity, temperature, dielectrica, vibration, displacement, conductivity, tachometry, seismography, capacitance, and liquid level is provided by a new ionization transducer. Instrument offers output signals as high as ±100v, better than average resolution, and high sensitivity. Other features are static and dynamic response, a phase sensitive dc output signal, reproducible performance, good linearity and miniaturization. Incorporated into an analog measuring system, transducer measures any phenomenon which can be resolved into changes of capacitance, resistance, inductance, or dielectric constant. Devices which have been built around the transducer include an angular pickoff system to solve research problems involving guided missiles, a seismograph displacement pickoff, and a tachometric system for a high speed rotating device.

Basically, transducer consists of two internal probe electrodes in a glass envelope filled with noble gases under reduced pressure. Gas is ionized by a radio frequency generator and external electrodes to produce ions and electrons. Space charge is created which is related to the electric field, and this charge furnishes the output signal. **Decker Aviation Corp.**, 1361 Frankford Ave., Philadelphia 25, Pa.

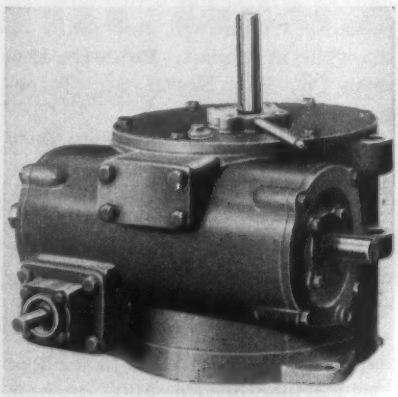
Circle No. **20** *on Reply Card*



Pneumatic Temperature Control

A non-bleed pneumatic temperature control is a differential expansion type instrument for precision regulation of heating, cooling, ventilating, air conditioning, dew point control, and industrial processes. Known as the Limitem, the instrument operates in the 35 to 135F temperature range, and sensitivity is adjustable from ⅛ to 2 psi per 1 degree temperature change. Concealed, graduated dial permits easy adjustment. Average bulb length is 18 inches with ⅜-inch pipe or flange connection, and body OD is 1¾ inches. Dept. ANC, **Powers Regulator Co.**, 3400 Oakton St., Skokie, Ill.

Circle No. **21** *on Reply Card*



Cam Operated Indexing Unit

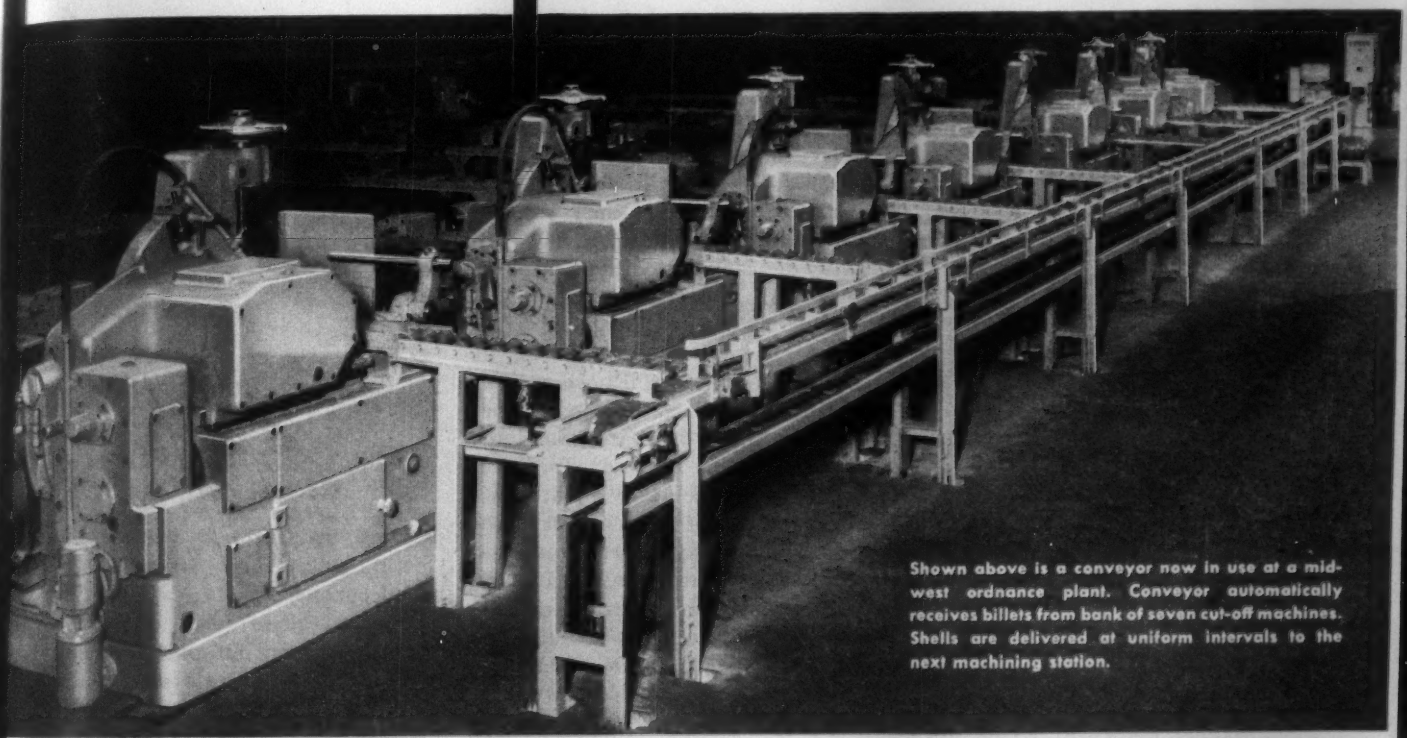
Designed to provide precision positioning between automatic production stations or to provide simplified means of timing production operation drives, new cam operated indexing unit is said to reduce machine design time by as much as 50 per cent. Accurate positioning for milling, drilling, soldering, crimping or assembly is provided at each index position. During a

"PRACTICAL ENGINEERED" CONVEYORS... now designed and built to fit your needs

IMPORTANT PART OF AN EXPANDED BUILDING SERVICE FOR AUTOMATION EQUIPMENT

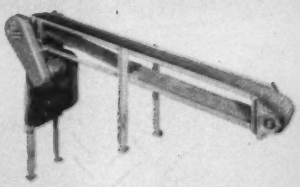
The Process Equipment Division of the W. F. & John Barnes Company now provides complete facilities for designing and fabricating standard or special conveyor units and systems. The four units illustrated are typical of the hundreds of conveyor installations designed and built from standard components to meet the exact need of the particular job to be done. Every Barnes unit is a "tailor-made" system that is "practical-engineered" to increase work handling efficiency by eliminating the more hazardous and laborious manual operations.

Here at Barnes, you'll find the varied engineering and creative skills, plus over 75 years of machine building background, to help you solve many troublesome production problems. And, because all planning, engineering, and manufacturing efforts are closely coordinated, you have available a complete "Automation Equipment Service" from one convenient source.

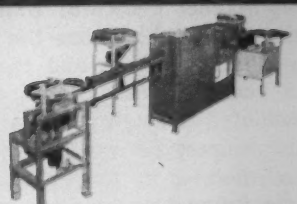


Shown above is a conveyor now in use at a mid-west ordnance plant. Conveyor automatically receives billets from bank of seven cut-off machines. Shells are delivered at uniform intervals to the next machining station.

A leading automotive manufacturer uses this Barnes Conveyor to carry cast iron chips away from machine tools. Chips are carried on a heavy drag-type conveyor-elevator and dropped in a tote box.



Shown here is a wire-mesh type, variable speed conveyor designed for carrying small work parts from a machine. It is widely used for general work-handling and can be built to handle the required length and width of the workpiece.



Here is a Barnes Conveyor in operation on an appliance production line. Metal cylinders are moved by the conveyor through a washer to the next point of operation.

ASK FOR AN ANALYSIS OF YOUR WORK-HANDLING PROBLEMS

Find out how these unique creative and specialized resources can help you cut costs. Your problem will be given expert and individual attention.

GET THIS *NEW* BROCHURE

Write today for copy of Conveyor Units and Systems. You'll find 27 solutions to material handling problems.

W. F. & JOHN BARNES

W. F. & JOHN BARNES COMPANY *Process Equipment Division*

414 SOUTH WATER STREET • ROCKFORD, ILLINOIS

BUILDERS OF BETTER MACHINES AND EQUIPMENT SINCE 1872

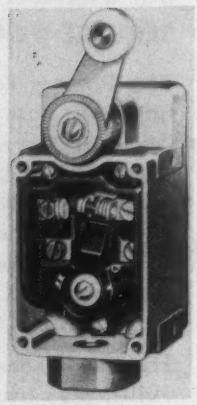
complete cycle, increments of 8, 12, 16 or 20 can be obtained. Worm and gear connections to the input shaft drive the cylindrical cam which in turn provides motion to the indexing table. Rotating shafts are mounted on tapered roller bearings to insure accuracy of all motions. Operation of auxiliary drives or other production devices are provided for through cam shaft extensions. Among typical uses of the unit are automatic assembly of electrical or mechanical components, and positioning for multiple operations on parts of equipment. **Standard Tool & Mfg. Co.**, 740 Schuyler Ave., Lyndhurst, N. J.

Circle No. 22 on Reply Card

Permanent Magnet Generator

Position of a rotating shaft is indicated by a miniature ac permanent magnet generator which provides two voltages, one the sine of the shaft position, and the other the cosine. Sliding contacts are eliminated through use of a permanent magnet for the rotor. Generator operates up to 6000 rpm with a maximum harmonic content of 3 per cent. Stainless steel ball bearings are used for corrosion resistance. Generator is available in diameters of 1.43 and 1.67 inches. Larger unit may be equipped with a seal at the terminal block end for use in hermetically sealed assemblies. **Arga Div., Beckman Instruments, Inc.**, 220 Pasadena Ave., South Pasadena, Calif.

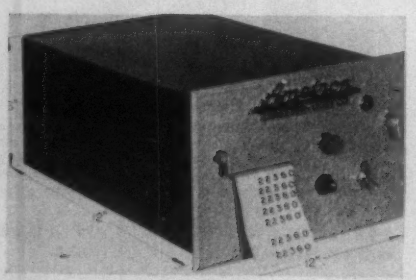
Circle No. 23 on Reply Card



Machine Limit Switch

Increased wiring space, protection against excessive overtravel achieved without shear pins, complete separation of electrical and mechanical mechanisms, and nylon to steel wearing surfaces are the features of a new heavy duty machine limit switch. Unit is rated at 10 amp continuous capacity up to 600v ac, 550v dc, and is available with ½ or ¾-inch conduit connections. Limit switch has a heavy die-cast case with an integral solid wall separating mechanical and electrical mechanisms. Overtravel mechanism has two sets of double concentric coil springs permitting continuous 30 degree overtravel without increasing maintenance problems or shortening life. Six optional back cover plates afford a variety of front and reverse-lever mounting arrangements. Available operating levers include four lengths of straight levers, track type, planer type, and shipper rod arms. **Clark Controller Co.**, 1146 E. 152nd St., Cleveland 10, O.

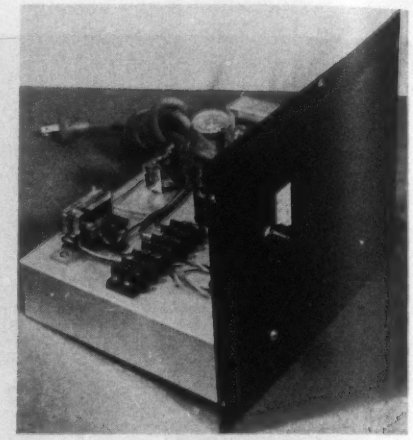
Circle No. 24 on Reply Card



Miniature Recording Counter

Although compact in size, 5 x 12 x 12 inches, miniature recording counter is capable of accepting pulses or contact closures at the rate of 1000 per minute. Proper coils may be furnished to facilitate actuation by a variety of input signals. Data are presented in 3/16-in. high numerals on 2¼-in. paper tape, and are also available on cards in another model. Solenoid type printer which may be actuated manually or automatically adds greater speed to data printout and eliminates lost counts. Recorder includes as standard feature an automatic reset. **Streeter-Amet Co.**, 4101 Ravenswood Ave Chicago 13, Ill.

Circle No. 25 on Reply Card

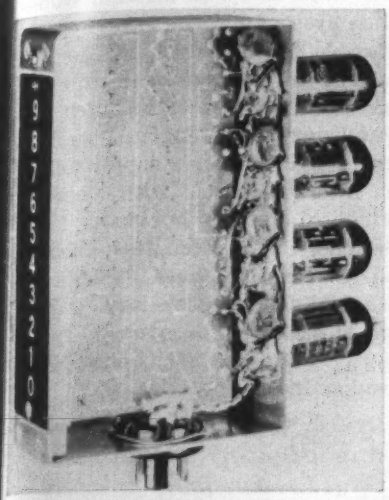


Electronic Overload Relay

Designed for use wherever fast acting and precise electrical overload protection is desired, electronic overload relay can operate with a current differential as small as 0.05 amp. Basis of unit is a thyratron control tube with a single pole double throw relay connected in its plate circuit. Operating characteristics of this tube can be varied by means of a control dial, calibrated in volts or amperes, so that tube will fire only after a certain voltage is applied to its grid circuit. Device can be set at higher control figure, so that small overloads will not actuate the device and stop the machine or motor to which the device is connected. Control tube will not fire until after an initial warm up period of approximately 10 seconds, which is longer than the duration of the usual motor starting currents. If a longer initial delay is required, a time delay element can

be furnished with the electronic relay. **Standard Electric & Mfg. Co.**, Investment Bldg., Pittsburgh 22, Pa.

Circle No. 26 on Reply Card



Digital Decade Counters

Two new type digital decade counters, each available in three variations, have been designed for use wherever high speed electronic counting is required. Both types employ the printed circuit principle, permitting maximum ventilation, lower operating temperature and longer life. Type "A" group has decades with a staircase output of voltage proportional to the count, enabling output of the decades to be recorded on an oscillograph. Type "B" group has decades with a four line coded output which can be used to operate mechanical printers. Both types are applied to high speed electronic counters which will accept input pulses at rates varying from 0 to 100,000 counts per second. For each ten pulses received at the input, one pulse is generated at the output. Addition of an external switching accessory permits selection of an output pulse at any value from 1 to 9. Two or more presetting accessories can be used on a single counter, permitting the setting of upper and lower limits for control applications. Reset to zero occurs on the tenth count or the unit can be forced to return to zero by an external pushbutton switch. **Brush Electronics Co.**, 3405 Perkins Ave., Cleveland 14, O.

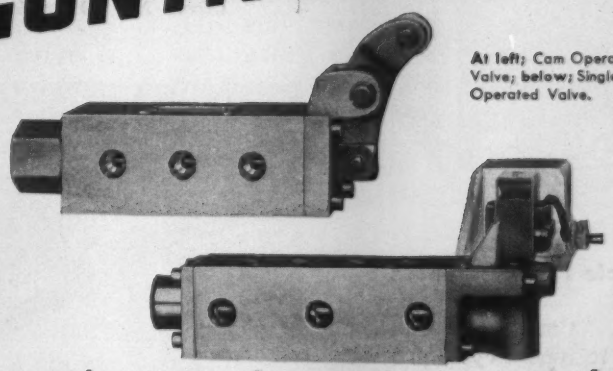
Circle No. 27 on Reply Card

SELECT

Quick-As-Wink®

AIR AND HYDRAULIC

CONTROL VALVES



At left; Cam Operated Type "O" Valve; below; Single Solenoid Pilot Operated Valve.

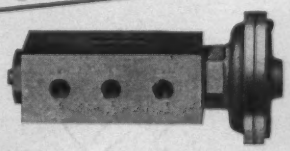
They're designed to give you the fast dependable trouble-free action you need

for single or sequence machine movements

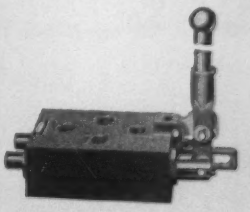
• Those successive and inter-related machine operations — that speed manufacture and cut costs — can only be as successful as the air and hydraulic valves that control the operations. Specify Quick-As-Wink Control Valves.

Positive and fast acting, Quick-As-Wink valves are designed and built to meet the most exacting requirements. They will deliver dependable and precision performance month after month, and year after year. Many superintendents and foremen have found that there is nothing better than a Quick-As-Wink valve. Can you afford to gamble with less? Get full details. Write for Bulletin No. 531 today!

Ask us also about . . .



DIAPHRAGM OPERATED "O-TYPE" VALVE, diaphragm can be actuated with instrument air as low as 12 to 15 psi.

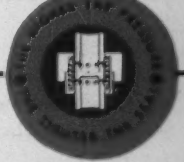


LEVER OPERATED HYDRAULIC VALVE suited for water or hydraulic-oils up to 5000 psi. 2-way, 3-way and 4-way actions.

Quick-As-Wink

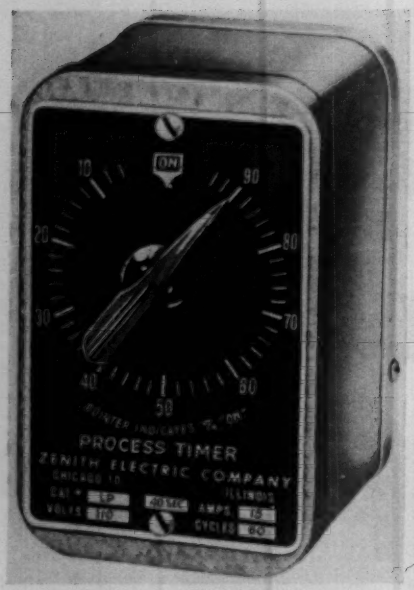
AIR AND HYDRAULIC

Control Valves



Hand, Foot, Cam, Pilot, Diaphragm and Solenoid Operated

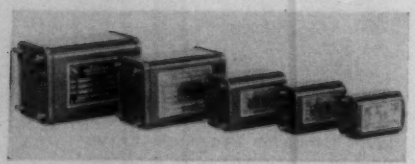
Mfd. by C. B. HUNT & SON, INC., 2077 East Pershing St., Salem, Ohio



Repeat Cycle Process Timers

Percentage timing feature has been added to repeat cycle process timers which operate continuously to turn circuits on and off for constant interval operation. Percentage timing provides constant accuracy in repeating operations, such as temperature control of radiant type heaters, hold fire controls, mixing machinery, testing equipment, fans, and reduces strain on electrical components. Time cycle ranges from 15 seconds to 24 hours, with adjustability for on or off periods up to 94 per cent. Timer has visible dial, snap action switch with silver contacts, synchronous motor and is compact—height, 5 inches; width, 3 inches; depth, 3 inches. **Zenith Electric Co.**, Dept. ANC, 152 W. Walton St., Chicago 10, Ill.

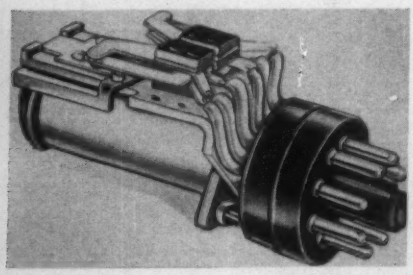
Circle No. **28** *on Reply Card*



Magnetic Servo Amplifiers

Line of magnetic servo amplifiers, designed for operation at high temperatures with no rectifiers, is available in wide variety of ratings. Amplifiers have output power ratings of 3, 6, 10, 15, 18 and 40w at 400 cps, delivering voltages of 0 to 26v, 0 to 38v, 0 to 115v and 0 to 220v. Output wave form is sinusoidal and phase reversing, according to input. Input signal may be ac or dc. Hermetically sealed units are designed for servosystems application and operate over ambient temperature range of − 55 C to 100 C. Service life approximates 20,000 hours. **Magnetic Research Corp.**, 200 Center St., El Segundo, Calif.

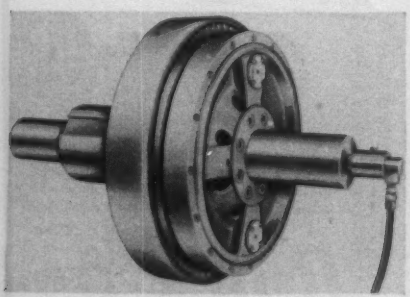
Circle No. **29** *on Reply Card*



Plug-In Relay

Open type, plug-in relays can be installed, inspected, or replaced without disturbing the wiring. Relays can be furnished with standard contact combinations up to 24 arms per relay, and for operating voltages from 6 to 230v, ac or dc. Standard contact ratings are 2 amp at 24v dc or 115v ac. Bifurcated contacts for extremely low voltage and low current or heavier contacts rated up to 5 amp can be furnished. Relay is 3½ inches long, 1⅛ inches wide. **Magnecraft Electric Co.**, 1442-V W. Van Buren St., Chicago 7, Ill.

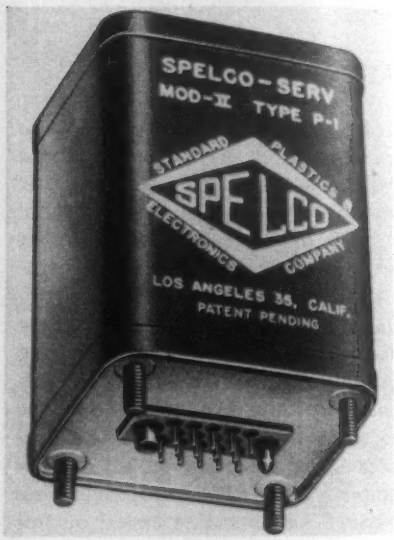
Circle No. **30** *on Reply Card*



Air-Grip Clutch

Finger-tip control and ability to be "inched" or thrown into full engagement instantly are featured in a new air clutch. In addition to its instantaneous response to throttle, clutch can be provided with optional, quick release valves which permit instant disengagement. Cool operation and long life are assured by an internal ventilation system and the location of the flexible air seal disk which never comes in contact with the heat generating plates. Clutch has provision to be engaged mechanically should the air supply fail. It is interchangeable with other mechanical clutches in existing installations, and occupies minimum space on the shaft. Single and double plate models are available from 8.5 to 806 hp per 100 rpm at 80 psi. **Dodge Mfg. Corp.**, Mishawaka, Ind.

Circle No. **31** *on Reply Card*



High Output Amplifier

Small enough for application to miniaturization programs, this modulator-amplifier has fractional watt input and 100 watt output. It will accept ac, dc, and phase-shift error or control signals as low as 50 mv, sense their phase or direction and supply output power at a gain of 300 to 1000 absolute value. Used with actuators, instrument sets up simple control or servo systems. It operates on a power supply with a frequency range of 200 to 800 cycles per second, can be supplied for 60 cycles. No preamplifier is necessary, and loads may be resistive or inductive. Unit can act as a relay with no

AIR CIRCUIT DESIGN AND COST SIMPLIFIED BY AIR CYLINDER WITH BUILT-IN VALVE . . .

In pneumatics operation the closer the valve to the cylinder, the quicker, more positive the action. In the Bellows Air Motor the valve is *integral with the cylinder.* This integral construction means instant action. No lag, no delay, no air flow restriction. Integral construction means positive control over piston rod direction . . . over piston rod speed. It means compactness — space-saving design . . . simplified installation in cramped quarters, or on moving machine elements.

Bellows Air Motors are available with a choice of built-in valve arrangements. Thus, the engineer can choose the method of valving he prefers, yet still have all the advantages of integral valve and cylinder construction. If he prefers momentary contact, low voltage control — Bellows has it. If he prefers maintained contact, 110 volt operation for simple interlock with established electrical circuits — Bellows has it. Or should his designs call for full pneumatically controlled operations Bellows offers a choice of proven control systems.

VALVE AND ALL OPERATING CONTROLS ARE INTEGRAL WITH THE CYLINDER.

WRITE FOR THIS FREE 36-PAGE BOOKLET

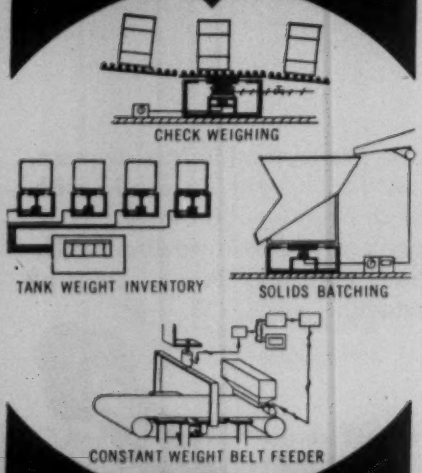
Here in these quick-reading pages is the story of the Bellows Air Motor—What it is doing for others—what it can do for you. No cost. No obligation. Address Dept. AU-355, The Bellows Co., Bellows Bldg., Akron 9, O.

The Bellows Co.

AKRON 9, OHIO

FIELD ENGINEER OFFICES IN ALL PRINCIPAL CITIES AND INDUSTRIAL AREAS IN THE UNITED STATES AND CANADA

W/C Electric Weigh Scale

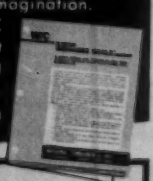


...complete
...self-contained
NEEDS NO ENGINEERED INSTALLATION

- Up to 10,000 lbs. gross capacity
- Guaranteed accuracy of entire system
- No effects from vibration
- No springs, levers, or knife edges
- Expert design of structures and circuits to fit individual requirements

Here's a system for batch or continuous process control that assures accurate net weights automatically, regardless of fluctuating tares. Electrical strain-gauge load cells of long-recognized accuracy are freed, through W/C pneumatic tare compensation, to respond only to net weights, thus using their effective range to measure only the variable controlling the process. Feeding belt conveyors, recording and controlling raw materials inventory, weighing finished packaged products to within 0.15% of gross — these typical applications of the W/C Weigh Scale should stimulate your imagination.

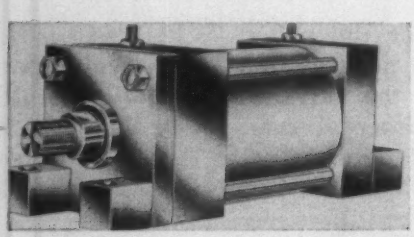
Find out how a W/C Electrical Scale can cut your process time and increase yield — inexpensively — by writing for Catalog 20.



WEIGHING COMPONENTS, INC.
64-G Fulmer Ave. • Hatboro, Pa.

moving contact points since no power is supplied the load in the null or standby condition. Operating temperature range is −90 to 300F. Models are furnished with externally mounted tubes for quick servicing or hermetically sealed. **Standard Plastics & Electronics Co.**, 1540 S. Robertson Blvd., Los Angeles 35, Calif.

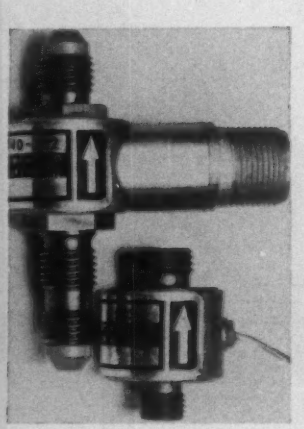
Circle No. **32** *on Reply Card*



Cylinder Mounting

Square mounting lugs mount flush with company's standard cylinder square heads and caps for strength and space economy in a new cylinder mounting. Lugs are quickly installed and are detachable for interchangeability with other mounting attachments. Low centerline height is machined to a tolerance of 0.002 in. Unit is available for side or foot mounting of company's line of "custom-built" air and hydraulic cylinders and is also available for all bore-and-stroke sizes of their stock cylinders. **Miller Fluid Power Co.**, 2040 N. Hawthorne Ave., Melrose Park, Ill.

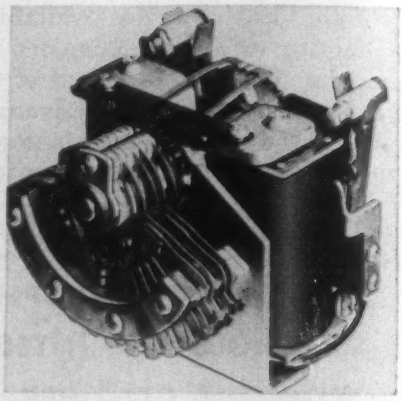
Circle No. **33** *on Reply Card*



Fluid Shutoff Valve

Said to be one-half the size and weight of most conventional type valves, a solenoid-operated shutoff valve has been successfully applied to aircraft service and can be used with any end product that has fluid handling problems. Flow passage, valve poppet, and valve seat are located within the core of the coil for a coaxial arrangement which permits minimum size and weight. More than 100 variations are available to suit particular problems, including up to ¾-in. tube size. Smallest unit weighs 1¾-oz, has a 1/32-inch diameter flow orifice, opens against 200 psi at 17v dc with an effluent temperature of 500F, and is furnised either normally open or normally closed. Valves can handle all aircraft fluids at pressures up to 3000 psi or more, and absolute zero leakage can be provided if required. **Aero Supply Mfg. Co. Inc.**, Corry, Pa.

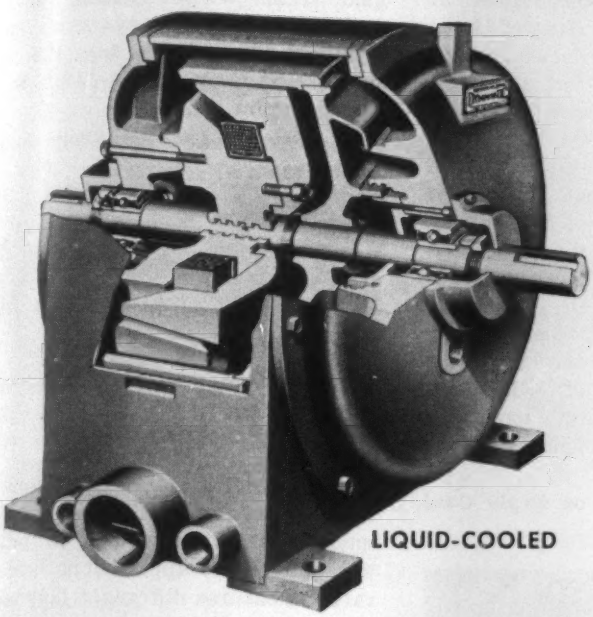
Circle No. **34** *on Reply Card*



Bidirectional Stepping Switch

Differential counting, remote selection under control of impulses, and adaptation as a digit storage register in automatic computers are typical applications of this bidirectional stepping switch. The small stepping motor is normally equipped with a four-level, 12-position bank and wipers. Wipers move when the coil is energized and cannot be positioned between steps. Shaft rotates either clockwise or counterclockwise in 10-degree increments under control of two electromagnets. Limit switches stop the switch at the end of the bank travel. Interrupter contacts can be furnished for self-stepping and for interlock to protect against partial steps. The stepping motors can be used to position servomotors or potentiometers, and coils

There are Hundreds of Uses for



LIQUID-COOLED

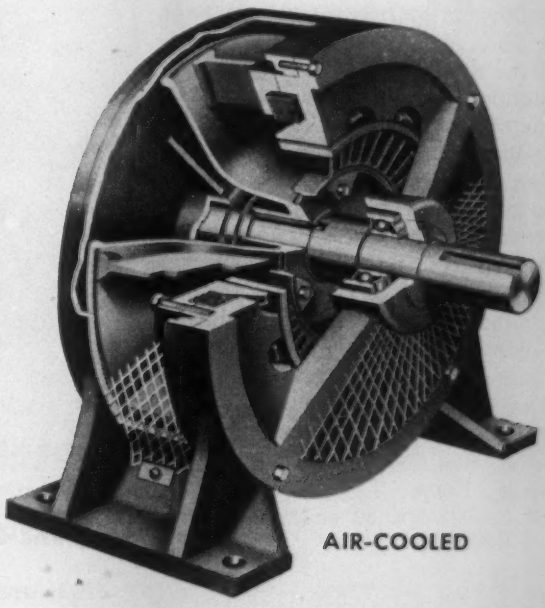
DYNAMATIC®

EDDY-CURRENT BRAKES

Wide range of torque capacities and operating speeds. Smooth, frictionless, shock-free operation. No rotating electrical components or contacts. Electronic or magnetic amplifier control from AC power.

Here Are Some Suggestions

Providing constant tension or constant linear feet per minute speed for unwind stands in metals, fabric, plastic, and paper industries.



AIR-COOLED

For accurately controlling lifting and lowering functions of cranes and hoists by creating an opposed load on a wound rotor motor.

Providing a controlled load for the production testing of engines, transmissions, or axles.

Smooth stopping of high inertia masses; precise control of deceleration with automatic or manual controls.

For Complete Information
Send for Your Copy of Our New Illustrated Bulletin No. BR-1

EATON®

EATON

DYNAMATIC DIVISION
MANUFACTURING COMPANY
3307 Fourteenth Ave. • Kenosha, Wisconsin
General Offices: Cleveland, Ohio

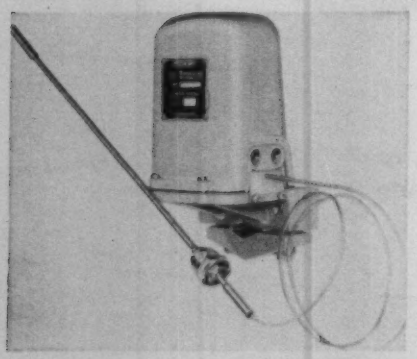
are available for dc voltages as high as 120 v. **Sterling Engineering Co., American Machine & Foundry Co.,** 54 Mill St., Laconia, N. H.

Circle No. **35** *on Reply Card*

Time Delay Relay

Calibrated dial on a new adjustable time delay relay features a positive detent for rapid, accurate adjustment. One model, which is adjustable from 2 to 30 seconds, is calibrated in 0.2 second increments. Accuracy is 1 per cent. Unit operates on 24 to 29v dc with a chronometrically governed motor. Standard connection is to screw terminals, and a solder type model is available. A flange is provided for panel mounting with the dial on the panel face. Relay is 4.25-inches long, enclosed in a 2.2-inch diameter aluminum housing. **A. W. Haydon Co.,** 232 N. Elm St., Waterbury, Conn.

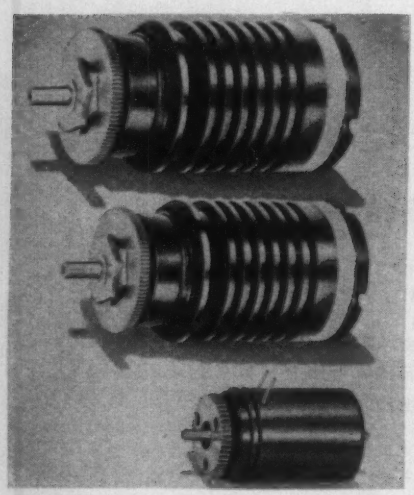
Circle No. **36** *on Reply Card*



Temperature Transmitter

Process temperatures are measured, and the information transmitted pneumatically to a central recording or controlling station by a nonindicating device. Transmitter is of the "force balance" type, and is designed around a gas filled thermal system which exerts force on a flapper-nozzle mechanism in proportion to the measured temperature. Resulting back pressure in the nozzle circuit is amplified through a relay and converted to a force through a bellows to balance out the initial force and constitute the 3 to 15 psi output. Calibrated accuracy is ½ per cent of the temperature span, and instrument is compensated for ambient temperature and barometric pressure variations. Spans are available ranging from 50 to 400F, can be utilized between the limits of −100 and 1000F. Block and clamp mounting arrangement is provided. **Foxboro Co.,** Foxboro, Mass.

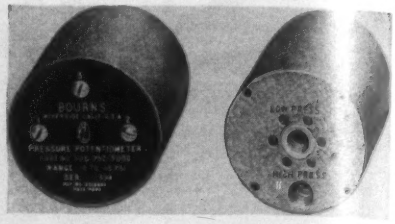
Circle No. **37** *on Reply Card*



Magnetic Clutch

High speed, precision magnetic clutch is available in three sizes for all types of electronic and electromechanical control systems, computers, servomechanisms, and tape and film drive applications. Miniature model is designed particularly for aircraft and missile service. Clutches are the friction disk type, and are available in sizes ranging from 1¼-inch diameter in the miniature model to 2½-inch diameter in the high torque model. Torque ratings range from 20 in.-oz to 125 in.-oz, and response times from 0.005 second to 0.025 second depending on torque requirements. Stationary dc coils are furnished in 12, 24, 48, 80, and 175v. The two smaller units can have output braked to ground when de-energized, if desired. All models have concentric input and output [illegible]afts on the same end for moun[illegible]g on gear trains with additiona[illegible]nits such as motors and synch[illegible] **Instrument Components, Inc.,** [illegible]lock **Instrument Corp.,** 14-34 11[illegible] St., College Point, N. Y.

Circle No. **38** *on Repl[illegible] Card*



Pressure Potentiometer

Differential pressure potentiometer, designed to withstand severe environmental conditions in missile and rocket applications, accurately measures difference between pressures applied to two pressure ports, such as fuel tank pressure, airspeed, or pressure drop across an orifice. Instrument features electrical contact arm with a counter-balanced linkage that pivots in a miniature, ball bearing assembly. Potentiometer weighs 7-oz, is 2¼ x 2⅜-inch, and has a power rating of ½-w at 160F. Specially developed beryllium copper diaphragm type bellows assures optimum linearity and repeatability with minimum hysteresis. **Bourns Laboratories,** 6135 Magnolia Ave., Riverside, Calif.

Circle No. **39** *on Reply Card*

Motor-Tachometer Combination

features standard dc motor outputs of 5 to 100 w for speeds to 10,000 rpm, with an operating voltage range of 6 to 220 v. **Electric Indicator Co., Inc.,** Springdale, Conn.

Circle No. **40** *on Reply Card*

Wide Band Electronic Switch

provides simultaneous viewing and comparison of two inputs; applications to overshoot, rise time and duration measurements; to shape time and amplitude comparisons; to simultaneous display of related waveforms; and to simultaneous display of non-synchronous signals. **Teletronics Laboratory, Inc.,** Westbury, N. Y.

Circle No. **41** *on Reply Card*

Selenium Rectifiers

which have oversize components and use no moving parts, are designed for industrial applications and include models such as fan cooled rectifiers, convection cooled rectifiers, combination convection-fan cooled rectifiers and water cooled rectifiers. **Walker Div., Norma-Hoffman Bearings Corp.,** Stamford, Conn.

Circle No. **42** *on Reply Card*

Differential Transformer

of the rotary variable type is designed for the continuous measurement and remote indication of the angular position of rudders, control surfaces of aircraft, valves and similar equipment. **Schaevitz Engineering,** Camden 1, N. J.

Circle No. **43** *on Reply Card*

Multiple Lugs

with available wire ranges for two 4/0 to two 1/0 cables are designed to permit the two cables to be installed in the space ordinarily required for one large cable. **Ilsco Copper Tube & Products, Inc.,** Mariemount Ave., Cincinnati 27, O.

Circle No. **44** *on Reply Card*

Delay Line

for use in color television broadcasting, radar scanning, high frequency oscilloscopes, and short-time memory systems, is a variable unit of distributed-constant electromagnetic type. **Helipot Corp.,** 916 Meridian Ave., S. Pasadena, Calif.

Circle No. **45** *on Reply Card*

Thermocouple Head

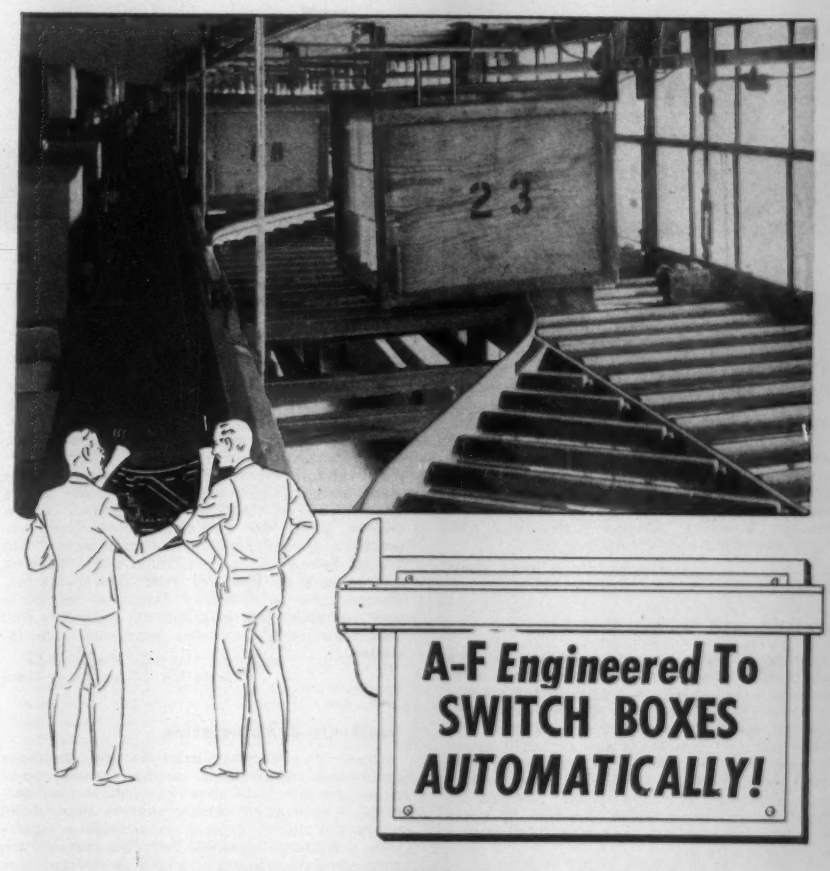
with closed case chrome finished for corrosion resistance, used for wiring connections to company's thermocouple glands and wells. **Conax Corp.,** 4515 Main St., Buffalo 21, N. Y.

Circle No. **46** *on Reply Card*

Anti-Backlash Gear Assembly

for applications where zero backlash is required, comprises two anodized aluminum gears rotated in opposite directions by stainless steel springs until they engage firmly with the mating gear. **PIC Design Corp.,** 160 Atlantic Ave., Lynbrook, L. I., N. Y.

Circle No. **47** *on Reply Card*



HOW New A-F Automatic System Increases Plant Efficiency, Lowers Costs!

TRAVELING TO their respective packing stations, these large, filled boxes switch themselves unerringly and *more quickly* than if "steered" by human beings. Yet there are no operators . . . the switching is done automatically!

HERE'S HOW: The main A-F Live Roller Conveying Line is equipped with automatic, air operated pick-up and roll-out sections. At the top of each box there are pins which strike triggers at each station. These operate an air cylinder which lifts the roll-out section so that it becomes a switch from the main conveyor.

Since 1901, Alvey-Ferguson has engineered every type of conveying system for every type of industry. A-F Engineers can help *you* to move loaded pallets from floor to floor more economically . . . route and switch "trains" of cases automatically or . . . engineer a completely co-ordinated Cleaning, Conveying and Processing System for your plant. For more details

. . . Write today

The Original Since 1901

THE ALVEY-FERGUSON CO.

171 Disney Street — CINCINNATI 9, OHIO

WEST COAST PLANT—760 N. Georgia Street, AZUSA, CALIFORNIA

new CATALOGS AND LITERATURE

Hydraulic Die Handling Trucks

Elwell-Parker Electric Co.—Among features of new line of hydraulic die handling trucks are independently operated pusher bars which make possible the turning of the die as it is pushed off the truck. Base position of truck platform is low in height, making the servicing of bed presses easier and more rapid. Die setting time with a 14,000 lb die is eight minutes. Brochure contains illustrations and design, operating and application data.

Circle No. 48 on Reply Card

Induction and Torque Motors

Electric Indicator Co., Inc.—Twenty-six page catalog discusses line of instrument type electric rotary equipment. Included in the catalog are physical characteristics, dimensional drawings and performance curves for induction and torque motors. Also listed are electrical specifications for induction units ranging from 1/1000 to 1/6-hp, for single, two and three phase operation, 15 to 400 cycles. Listings for torque motors cover broad selection of types and sizes for operation under stall conditions and reverse rotation.

Circle No. 49 on Reply Card

Transformer Catalog

General Transformer Co.—Twenty-page catalog provides information on transformers of various constructions, mountings, and electrical variations. Among those described are filament, plate filament, filter choke, autoformer isolation, high fidelity output and television transformers. Specifications and photographs of all models are included, along with applications and other descriptive data.

Circle No. 50 on Reply Card

Electronic Painting System

Ashdee Electrostatic Products, Inc.—Eight-page brochure outlines process for applying paints, varnishes and enamels on metal. Conventional automatic spray guns and equipment are said to be made more efficient through the use of a high voltage electrostatic field which puts a higher percentage of the coating material on the ware. Basic elements of the system are a spray gun to project the paint toward the ware, a conveyor system to move the ware past the gun, ionizing electrodes to charge the paint particles and a ground electrode to attract and collect the paint particles. Brochure includes description of the system, sketches illustrating different stages of the process, and photographs of the equipment used.

Circle No. 51 on Reply Card

Automatic Control Equipment

Dept. ANC, Zenith Electric Co.—Eight-page brochure describes line of automatic control equipment. Automatic transfer switches, mechanically and electrically held, remote control switch, magnetic contactor, magnetic solenoid contactors, program timers, one day and calendar time switches, interval timer, reset timer, multiple circuit timer and reversing control are among the equipment discussed. Each device is photographically shown, and specifications, applications, and operational information are given.

Circle No. 52 on Reply Card

Engineering Service Bulletin

Standard Tool & Mfg. Co.—Twenty-two page bulletin illustrates company facilities for designing, developing and manufacturing automatic machinery, assemblies or subassemblies, and component machine parts. Electric controls ranging from simple pushbutton to the most intricate and sensitive electrical panels are illustrated. Among those shown are a control panel for automatic production machine, a processing panel with integral cam timing device and an electronic panel showing adaptability to standard rack type mounting. Photographs of company facilities, personnel and products, lists of company customers and specifications of available equipment are included.

Circle No. 53 on Reply Card

Sectionized Automation

Cross Co.—Fourteen-page bulletin discusses sectionized automation, a new development based on the division of a machine into sections, any one of which can be shut down while the others remain in automatic operation. Bulletin uses as an illustration the Transfermatic machine, which is divided into five sections. Pictures of the different sections in operation are given, along with illustrations of component parts. Purpose of sectionized automation is to minimize lost production during periods of downtime.

Circle No. 54 on Reply Card

Controlled Volume Pumps

Milton Roy Co.—Two-page data sheet describes the use of controlled volume pumps to control low capacity flows in continuous phosphatizing, a process in which a paint retentive, corrosion resistant coating is bonded to metal surfaces. In pickling and phosphatization, four chemical reagents are controlled: inhibitor, primer, toner and phosphatizing. Diagram shows controlled volume pumps in application.

Circle No. 55 on Reply Card

Process Control Power Operators

Conoflow Corp.—Pneumatically positioned power operator, the "Cylinder Conomotor," for throttling control service is described in 12-page bulletin. Conomotor's applications include proportional control of speed changers, valves, pumps and electrical components. Device consists of a specially designed cylinder, a piston with O-ring seal, an integral high capacity positioning device and a "cushion" loading regulator. Features and specifications of Conomotor are given, along with photographs of the device illustrating its different applications.

Circle No. 56 on Reply Card

Rotary, Multipole Switches

Electro Switch Corp.—Complete wiring diagrams and contact charts for voltmeter, ammeter, and voltmeter-ammeter switches are included in 12-page brochure. Rotary, multipole switches are designed to give low cost switching in complex circuits, using a single switch for control of multiple circuits. Detailed drawings of snap action and detent action switches are given, with handle and panel mounting data, physical dimensions, special switch information and electrical ratings.

Circle No. 57 on Reply Card

Charts for Recording Instruments

Technical Charts, Inc.—Twelve-page catalog contains information on recording charts for standard and special instruments. Samples of dial and roll type charts are included. Brochure also outlines technical information on the requirements for special charts. Company maintains file of over 8000 precision plates for their recording charts.

Circle No. 58 on Reply Card

Adjustable Speed Drive Couplings

Dynamatic Div., Eaton Mfg. Co.—Liquid cooled, eddy-current couplings which are adaptable to most adjustable speed requirements are described in 12-page booklet. Stationary field power transmission devices have no rotating electrical components, and are designed for all types of electronic or magnetic amplifier controls to accomplish most industrial processing requirements. Booklet contains complete information, including construction details, capacities, characteristic torque curves, dimensions, efficiencies and advantages, of the adjustable speed drive.

Circle No. 59 on Reply Card

Low Pressure Cylinders

NOPAK Div., Galland-Henning Mfg. Co.—First in a series of new catalogs on company lines of air or hydraulic cylinders and valves, catalog 101 contains information on low pressure cylinders which have 650 psi maximum. Future catalogs will be devoted to operating valves, pilot-pressure and bleeder operated slide valves and square head cylinders. Catalogs are designed to fit into a binder.

Circle No. 60 on Reply Card

Rotary Type Power Supplies

Carter Motor Co.—Twenty-eight page, illustrated catalog describes complete line of dynamotor power supplies. Dynamotors are used in aircraft communications, marine direction finders, police radio networks, railroad communications, ignition and timing equipment, etc. Photographs, electrical and mechanical specifications, and applications of 12 models are given. Among new models illustrated are the "Change-A-Volt" dynamotor, by which it is possible to use present 6v mobile radio equipment in the new cars without rewiring or tube replacement, and the "Duovolt and Duovolt Super Genemotors," which when specified as power supply on new set installations, perform equally well on either 6 or 12 v.

Circle No. 61 on Reply Card

Feeder Temperature Control

Leeds & Northrup Co.—Details on the combination of Rayotube detectors and Speedomax electronic recorders for control of glass feeder temperatures are contained in four-page brochure. Among features of Speedomax are proportioning, automatic reset and rate control actions. Photographs and specifications of two units are included in the brochure.

Circle No. 62 on Reply Card

Permanent Magnet DC Motors

Barber-Colman Co.—Nineteen-page catalog describes line of permanent magnet dc motors with outputs up to 1/10 hp. Data sheets on typical motors from 6v to 115v dc are included. Units are designed to power electro-

HERE IS THE LATEST IN AUTOMATION "HOW TO"

mechanical actuators, transfer switches, programming devices, and for use as tachometer generators. Descriptions of motors having radio noise filters, gear heads and centrifugal blowers are included.

Circle No. 63 on Reply Card

Permanent Magnetic Pulleys

Homer Mfg. Co., Inc.—Nonelectric permanent magnetic pulleys which automatically remove tramp iron from sand, slag, ore, chemicals, coal, cement, gravel, foods, feeds, etc., and separate ferrous from nonferrous materials are the subject of an eight-page bulletin. Photographs, applications and specifications of various size models are included. Performance data and a guide for selecting proper size are also given.

Circle No. 64 on Reply Card

Shell Thread Rolling Machine

Waterbury Farrel Foundry & Machine Co.—Automatic, inclined shell thread rolling machine is the subject of a four-page brochure. Rolling machine is connected to an eyelet machine, then automatically rolls the required thread on hollow metal parts produced by the eyelet machine. Shell threader can also be arranged for independent hopper feed. Brochure discusses use, construction, operation, drive and tooling of thread rolling machine. Table of specifications including capacities for two sizes is included.

Circle No. 65 on Reply Card

Relay Selection

Automatic Switch Co.—Selection of magnetically or mechanically held relays is the subject of two-page brochure, "Relay Selection Tabulations." Proper relay selection is said to require evaluation of the maximum current which the relay will be required to "make," the maximum current which the relay must carry continuously, and the maximum current which the relay must break. Included in the brochure are six circuit diagrams, three each for magnetically and mechanically held relay control forms.

Circle No. 66 on Reply Card

Air Data Computer

Servomechanisms, Inc.—Master air data computer which provides one co-ordinated source of information and eliminates duplication is the subject of an eight-page brochure. Schematic diagrams which illustrate how the plug-in type computer permits calculation of complex functions are included. Brochure contains photographs of the air data computer in application.

Circle No. 67 on Reply Card

Hydraulic Multipress

Denison Engineering Co.—Twenty-four page brochure describes applications of hydraulic multipress and its accessories. Among uses of machine are broaching, forming, compacting, nibbling, shaping, blanking, staking, embossing, marking, bending, cleaning, etc. Press has manual or automatic control, vibratory ram action, adjustable speeds and ram reversal adjustment. Accessories available include an index table, a dial feed table, stock feed and foil marking accessories. Brochure contains photographs of machine in actual applications.

Circle No. 68 on Reply Card

Selecting Cemented Carbide Grades

Carboloy Dept., General Electric Co. — Twenty-four page brochure discusses the methods for selecting the proper grade of cemented carbide for use as cutting tools. Included is information on determining efficient cutting speeds for machining steel, cast iron and nonferrous materials, calculating machine horsepower, choosing carbide grades by characteristics, and selecting rake and relief angles of carbide tools. Reference tables cover speed and grade suggestions for cutting various materials. Brochure is supplement to section 3 of Carboloy tool manual, GT-191.

Circle No. 69 on Reply Card

Electronic Gager System

Helipot Corp.—Four-page brochure discusses electronic gager system which is used in pipeline operations. Gager warns when oil tanks are nearly empty or full and controls the flow accordingly. Brochure describes principles of operation, equipment and circuitry. Gager system, made by Vapor Recovery Systems Co., also makes uses of Helipot precision potentiometers. Photographs and charts showing installation of gager system are included.

Circle No. 70 on Reply Card

Proportional Pacing of Chlorinizers

Builders-Providence, Inc., Div., B-I-F Industries, Inc.—Several automatic pacing systems for chlorine feeders are described in four-page brochure. Systems assure constant chlorine dosage regardless of variations in flow being treated. Brochure covers the flow responsive device, the converter and chlorine feeder best suited to the application. Photographs and typical installations are illustrated.

Circle No. 71 on Reply Card

Analytical and Control Instruments

Consolidated Engineering Corp.—Illustrated, 12-page catalog contains information on analytical, isotope ratio, dual purpose and process monitoring mass spectrometers; high vacuum leak detectors; sulfur recorders and high speed analog-to-digital converters. Use of analytical and control instruments in production, testing, monitoring and control phases of industry is discussed. Photographs of various models in application are also included.

Circle No. 72 on Reply Card

Plug-In Bus Duct

Continental Electric Equipment Co.—Twenty-four page bulletin discusses plug-in bus duct which is designed for low voltage branch distribution jobs. Connections of 10 ft lengths of duct can be made from either side. Types of tap boxes, end closers and plug-in units employed are illustrated. Elbow, tee and cross fittings are also shown, along with transformer taps, flanges and switch board stubs. Dimensional data and specifications are included.

Circle No. 73 on Reply Card

Water-Cooled Lens System

Engineering Products Div., Radio Corp. of America — Designed for use with industrial television equipment, water-cooled lens system permits direct viewing of furnaces, boilers and other operations. Two-page bulletin contains photographs, specifications and a schematic drawing of a typical installation of the unit. A closed circuit water circulating system is used to maintain camera temperatures below 120F in viewing temperatures ranging up to 3000F.

Circle No. 74 on Reply Card

Pulse Generators

Electronic Instruments Div., Burroughs Corp.—Three pulse generators which collectively cover a frequency range from 15 cycles to 4.5 megacycles are discussed in a six-page brochure. Modes of operation included in these three units are free running, pushbutton operated, or triggered by external synchronized pulses. All three are designed for mounting in standard 19-inch relay racks. Other units which can be assembled in pulse systems are flip-flops, pulse gaters, pulse delay lines, coincidence detectors and counters. Brochure includes specifications, photographs and assembly instructions.

Circle No. 75 on Reply Card

Electromechanical Amplifier

Electomic Designs—Designed as a control for machines, mechanisms, and instruments where a source of torque is available or a rotating device is employed as a source, electromechanical amplifier is used with computers and calculators, guided missiles, radar and aircraft equipment. Four-page brochure describes operation of the amplifier and its applications. Charts and diagrams illustrate features of the device.

Circle No. 76 on Reply Card

Wire Straightening, Cutting

Lewis Machine Co.—Line of wire straightening and cutting machines is described in two-page brochure. Machines will process all sizes of wire and rod, and are equipped for either stationary or high speed flying shear type cut-off. Photographs of the smallest and largest models in the line are included, along with specifications of 14 other models.

Circle No. 77 on Reply Card

Amplifying Comparator

George Scherr Co., Inc. — Amplification mechanism which features a cable release lifting the contact point by remote control, is the subject of a two-page brochure. Comparator has a range of 0.004-inch and is graduated in 0.00005-inch. Mechanism consists of a double lever, gear segment, pinion and hand. Measuring pressure is transmitted by a precision ball over a highly lapped plane surface. Photographs of comparator are included.

Circle No. 78 on Reply Card

Automatic Reset Dial Timer

Automatic Temperature Control Co., Inc.—Miniaturized dial type reset timer for industrial process, laboratory and machine automation is the subject of a six-page brochure. Timer is a synchronous motor-driven unit for control of ac or dc loads within variable timed intervals or sequences. Brochure includes electrical data, applications, basic circuit arrangements and table of standard dials.

Circle No. 79 on Reply Card

Metal Processing Machinery

Stanat Mfg. Co.—Laboratory and production rolling mills, rotary gang slitters, bull blocks, levelers, payoffs and accessory equipment are

NEW CATALOGS AND LITERATURE

discussed in four-page brochure. Slitting equipment is used for materials varying from stainless and silicon steels to plastics and wire cloth. Brochure contains photographs and operational data of numerous models.

Circle No. 80 on Reply Card

Hydraulic Cylinders

Vickers, Inc.—Five mounting styles are available in compact hydraulic cylinders: foot (bracket), flange (head end), flange (rod end), extended tie rod and clevis. Eight-page brochure includes engineering data, ordering instructions, and schematic diagrams which illustrate principles of differential oil-hydraulic circuits. Charts for determining piston areas, piston speeds and output forces for cylinders for both standard and heavy duty piston rods are also given. Cylinders are designed for general industrial applications.

Circle No. 81 on Reply Card

Electronic Process Control

Manning, Maxwell & Moore, Inc.—Thirty-page brochure discusses electronic communication in process control, and the elements and features of electronic process control instruments. Among the instruments covered are a miniature recorder, a recording control station, and indicating control station, a manual positioner and a valve positioner. Construction features, photographs, operating specifications and characteristics of all the units are included.

Circle No. 82 on Reply Card

Stock Components Catalog

Globe-Union, Inc.—Revised 48-page catalog contains photographs and technical data on company's five complete lines of stock components. Among new developments illustrated in the 1955 catalog are snap-tite controls, the senior compentrol, a new line of 1000 v disc capacitors, switch, capacitor and PEC kits, and negative 330 and 1500 TC tubular capacitors. Thumb index provides easy reference to desired line of components.

Circle No. 83 on Reply Card

Magnetic Separators

Eries Mfg. Co.—Information on the installation, technical data, specifications and available sizes of plate magnets, magnetic humps, grate magnets, pipeline traps, ferrous cleaners, micromagnetic separators, magnetic pulleys, drums, sheet fanners, sweepers, hoppers, slurry drums, and a magnetic separator with a built-in load alarm is given in a 16-page catalog. Photographs illustrate magnetic separators in actual applications.

Circle No. 84 on Reply Card

Packaged Control Systems

John C. Whiddett Co.—Four-page brochure photographically illustrates control problems and their solutions through company packaged control systems. Illustrations include a level control system in a weather tight case; dust, weather, and water resistant housings for photoelectric control systems; an explosion proof housing for a level controller, electronic timer or photoelectric control; and a probe assembly for use with an electric level control.

Circle No. 85 on Reply Card

Feeding, Straightening Machines

F. J. Littell Machine Co.—Four-page brochure discusses hydraulically driven feeding and straightening machines. Machines are said to be extremely useful where quick conversion from hand fed to automatically operated punch presses is desirable. Machines handle coil stock up to 0.125-inch thick. Brochure includes photographs of both models and lists their specifications.

Circle No. 86 on Reply Card

Custom Engineered Transformers

Electran Mfg. Co.—Transformers as large as 50 kva, single or polyphase, are designed by company to meet special transformer problems. Six-page brochure, A-54, also shows photographs and information on saturable reactors; filter reactors; charging chokes; electronic assemblies; special windings; resistive load banks; plate, power, filament, rectifier and vibrator transformers. Also discussed are audio, interstage, driver, modulation, oscillator and matching transformers. Company impregnating, potting, casting and capsulating equipment is discussed. Brochure includes list of industries served and check list for customer who orders special equipment from company.

Circle No. 87 on Reply Card

Temperature Transmitter

Moore Products Co.—Eight-page brochure discusses temperature transmitter which transmits a 3 to 15 psi air-pressure range. Unit uses pneumatic indicator, recorder or controller as the receiving instrument. Specifications, applications, photographs and schematic drawings of the transmitter are included.

Circle No. 88 on Reply Card

Principles of Chlorine Gas Feeders

Builders-Providence, Inc., Div., B-I-F Industries, Inc.—Twelve-page bulletin is a reprint of a paper by R. W. Pearce. Paper gives basic chlorine feeder information, and contains special reference to the applications of chlorine in the treatment of industrial waste. Among the subjects covered are the handling of chlorine, dissolving chlorine, withdrawing gas from containers, types of feeders and their operation, and feeder installation. Photographs, diagrams, tables and flow sheets are used to illustrate the article.

Circle No. 89 on Reply Card

Air Hydraulic Pumps

Powermatic Sales Co.—Four-page brochure describes air hydraulic pump which is designed for small volume high pressure duty. Pump contains bleed off valve and variable pressure control valve which give positive control. Brochure includes specifications, photographs and sketches of pumps.

Circle No. 90 on Reply Card

Rotary Air Equipment

Gast Mfg. Corp.—Eleven-page brochure includes description of the following rotary equipment: air motors, air compressors, and vacuum pumps. Air motors can be used on agitators, mixers, concrete vibrators, liquid pump drives, etc.; air compressors are designed for aerating, atomizing, embalming by pressure injection of fluids, and pneumatic controls; vacuum pumps are used in air bubble removal from wet mixtures, collators, milk bottle capping, hospital surgical anesthesia cabinets and machinery controls. All three items of equipment are available in various sizes and types. Brochure includes photographs of rotary equipment in 35 applications and specifications of various models.

Circle No. 91 on Reply Card

Temperature Detectors

Leeds & Northrup Co.—Two-page data sheet describes temperature detectors which respond to radiated heat energy and measure the temperature of either stationary or moving surfaces in many industrial applications. Detectors can be used for either direct sighting applications or for sighting into closed end target tubes to measure the temperature of a furnace atmosphere or other medium. Included are specifications, photographs and assembly information on several models.

Circle No. 92 on Reply Card

Fluid Power Devices

Modernair Corp.—Information on line air and hydraulic cylinders, valves and pa ged fluid power devices is given in 120 page ose leaf catalog. Divided into 14 sections, alog contains operating data, dimensions, o onal mountings and miscellaneous informati re- quired by designers and users of fluid wer devices. Manual is designed for easy up ting as new products or modifications ar an- nounced.

Circle No. 93 on Reply ard

Sling Chains

Columbus McKinnon Chain Corp.—Diag ams, charts and tables on standard and special styles of sling chains and attachments are given in 32-page bulletin. Also included is information on their sizes, weights and working load limits under many conditions of use. Handbook type data on care, use and inspection of sling chains are provided. Instructions for ordering sling chains are listed.

Circle No. 94 on Reply Card

Voltage Stabilizers

Raytheon Mfg. Co.—Sixteen-page catalog discusses voltage stabilizers, types available and their applications. Stabilizers are automatic, maintain constant ac output voltage, and have wide ac input voltage limits. Voltage stabilizers are used in television, colorimeters, radar and radio, signal systems communications apparatus, etc. Photographs, performance curves, and dimensions of various models of stabilizers are included.

Circle No. 95 on Reply Card

Automatic Gaging, Size Control

Taft-Peirce Mfg. Co.—Four-page brochure covers air electric gage which is designed for rapid production measurement from simple diameters to complex multidimensional checks. The gage, called a CompAIRator uses sensitive diaphragms to convert air flow to electrical impulses. Photographs illustrate CompAIRator as a gaging station for a multistation transfer machine, an automatic lathe for continuous size control of parts, and as a bearing checker on automotive cylinder blocks.

Circle No. 96 on Reply Card

Subminiature Switches

Micro Switch Div., Minneapolis-Honeywell Regulator Co.—Illustrated twelve page catalog is devoted to discussion of subminiature snap-action precision switches, auxiliary actuators, subminiature switches, toggle and push-button subminiature switch assemblies. Switches are designed for use in aircraft, guided missiles, electronic computers and radio installations. Catalog gives information on the standard subminiature, single-pole, double-throw switch as well as the long life, high temperature and turret terminal models of the switch. Photographs, specification charts and applications of the switches are included.

Circle No. 97 on Reply Card

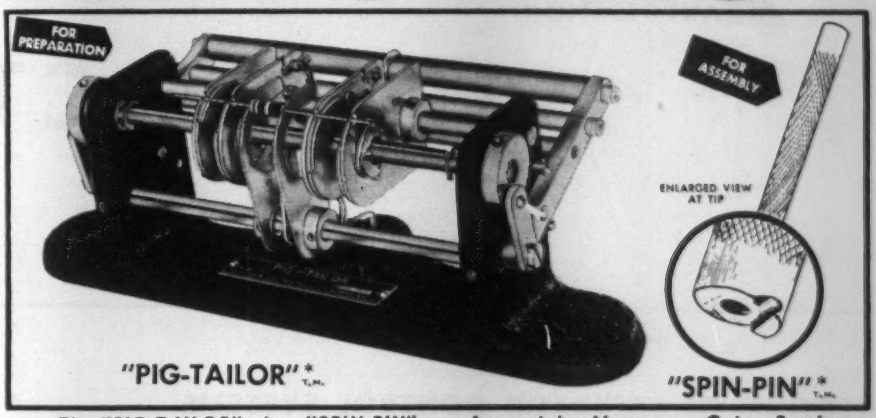
High Speed Gear Production

Michigan Tool Co.—High gear production potential makes high speed gear hobber practical for automatic gear production. Hobber is single spindle and will hob up to 8-pitch spur and helical gears having diameters of 5 inches and face widths of 4 inches. Eight-page bulletin includes diagrams showing the operating functions of the machine's universal spindle head design, its drive and hydraulic systems. Mounting of workpiece horizontally between automatic work holding centers simplifies automatic loading and unloading of gears. Photographs of gear hobber in application are included.

Circle No. 98 on Reply Card

"PIG-TAILORING"

. . . . a revolutionary new mechanical process for higher production at lower costs. Fastest PREPARATION and ASSEMBLY of Resistors, Capacitors, Diodes and all other axial lead components for TERMINAL BOARDS, PRINTED CIRCUITS and MINIATURIZED ASSEMBLIES.



The "PIG-TAILOR" plus "SPIN-PIN" — Accurately Measures, Cuts, Bends, Ejects and Assembles both leads simultaneously to individual lengths and shapes — 3 minute set-up — No accessories — Foot operated — 1 hour training time.

PIG-TAILORING provides:

1. Uniform component position.
2. Uniform marking exposure.
3. Miniaturization spacing control.
4. "S" leads for terminals.
5. "U" leads for printed circuits.
6. Individual cut and bend lengths.
7. Better time/rate analysis.
8. Closer cost control.
9. Invaluable labor saving.
10. Immediate cost recovery.

PIG-TAILORING eliminates:

1. Diagonal cutters.
2. Long-nose pliers.
3. Operator judgment.
4. 90% operator training time.
5. Broken components
6. Broken leads.
7. Short circuits from clippings.
8. 65% chassis handling.
9. Excessive lead tautness.
10. Haphazard assembly methods.

* PATENT PENDING

Write for illustrated, descriptive text on "PIG-TAILORING" to Dept. A3-P

BRUNO-NEW YORK INDUSTRIES CORPORATION
DESIGNERS AND MANUFACTURERS OF ELECTRONIC EQUIPMENT
460 WEST 34th STREET • NEW YORK 1, N. Y.

Miniature A.C. 60 Cycle MOTOR with Planetary Gear Reducer

Constant Speed

High Output Torque

Long Life

Precision-built hysteresis-synchronous motor provides constant speed from no-load to maximum rated torque. Furnished for single phase capacitor-run operation for 1800 and 3600 RPM motor speed at 60 cps. Units are also available for 2 or 3 phase operation. Winding is for 115V A.C., and may be varied for special applications. Planetary gearing provides 18 standard speed reduction ratios from 18.78:1 to 21,808:1. Output torques range from 12 oz. in. to 1000 oz. in. Diameter 1¼". Length depends on ratio. Weight 9 to 12½ ozs. Service life up to 5000 hrs. Units meet military specifications. *Write for details today!*

GLOBE INDUSTRIES, Inc.
1801 STANLEY AVE., DAYTON 4, OHIO

NEW MARSH
Serviceman Soundscope

. . . cuts servicing and maintenance costs

Most effective instrument ever developed for pin-pointing and identifying mechanical defects. Saves time and dollars tracking down troubles in bearings, gears, mechanisms . . . detects leaks, knocks, piston slaps—any defects that make a sound. A precision instrument of Marsh quality, sensitive to faintest sounds . . . with handy probe and headband as illustrated. A remarkable tool, moderately priced.

MARSH INSTRUMENT CO.
Sales affiliate of Jas. P. Marsh Corporation
Dept. X, Skokie, Illinois

Ask for Circular

AUTOMATION

ABSTRACTS

TESTING OF FEEDBACK CONTROL SYSTEMS

by T. A. WESTOVER
Servo Corp. of America
New Hyde Park, N. Y.

PERFORMANCE evaluation of a feedback control system usually consists of testing this system under simulated or actual operating conditions. The term feedback control system includes a large class of devices, such as regulators, governors, process controls, positioning servomechanisms, and so on. Explicitly, a feedback control system is a control system which tends to maintain the relationship of one system variable to another by comparing functions of these variables and using the difference as a means of control. There are an unlimited number of different systems and devices which are properly classified as feedback control systems. The general field of feedback control-system engineering can be applied to almost every known science and industry.

Analysis of linear systems has developed two methods of attack which can be used in system design; transient analysis, and steady-state, frequency-response analysis. Steady-state, frequency-response methods of analysis and synthesis have generally been found to be more easily applied, although in many cases, the system to be designed is one in which an optimum response to a suddenly applied signal or load is required. Methods for correlating transient and frequency response have been developed.

Both steady-state frequency-response and transient-response data are useful in the design of a feedback control system. While, in most cases, frequency-response data may be more valuable during the analysis and synthesis work, transient-response data may be ultimately required for performance evaluation. It is the purpose of this paper to describe methods and equipment useful in obtaining frequency-response and transient-response data.

Test Equipment

Equipment required for measurement of frequency response includes a sine wave signal generator with means for advancing the phase angle of this signal with respect to a time base or reference signal, also provided, and a cathode-ray oscillograph or recording oscillograph. Most of the necessary requirements for servomechanism testing may be provided by one instrument which is a combined signal generator and calibrated signal phase shifter and cathode-ray indicator. A complete block diagram is shown in *Fig.* 1.

The instrument contains two synchros with their stator windings connected together in the conventional manner. The rotor of one synchro is driven by a variable-speed drive, consisting of a servo amplifier, servomotor, and tachometer generator. The rotor of the driven synchro is excited externally from the servo power line for use with testing ac control systems and from an internal 3900-cycle oscillator for generating low-frequency signals to test dc control systems. Attached to the shaft of the rotating synchro is a synchronizing switch used to trigger a saw-tooth signal generator.

Modulation signal frequency may be varied by a factor up to 200 (0.1 to 20 cps or 0.15 to 30 cps) by controlling the speed of the velocity servo through an input potentiometer. Another potentiometer on the same shaft is used to control the time constant of the electronic sweep circuits.

Thus the instrument generates synchronously two signals, a sinusoidally modulated suppressed carrier signal and a saw-tooth signal whose amplitude is constant and whose period is equal to one cycle of the modulated signal. However, by means of the phase dial synchro, the envelope of modulating signal may be made to lag or lead in phase or time the saw-tooth signal. The sinusoidally modulated suppressed carrier signal is applied to the vertical plates and the sweep signal is applied to the horizontal plates of a cathode-ray oscilloscope, a pattern resulting on the cathode-ray oscilloscope.

Frequency Response Test

With the equipment connected as shown in *Fig.* 2, the amplitude of the input signal under test is set at a value which will not cause saturation in the servoamplifier due to the maximum anticipated eror signal in the servoamplifier, or in the motor by requiring velocities and accelerations of the motor shaft which the motor is incapable of delivering.

Frequency of the input signal to the system is set at a low value compared to the resonant frequency of the servosystem and the pres-

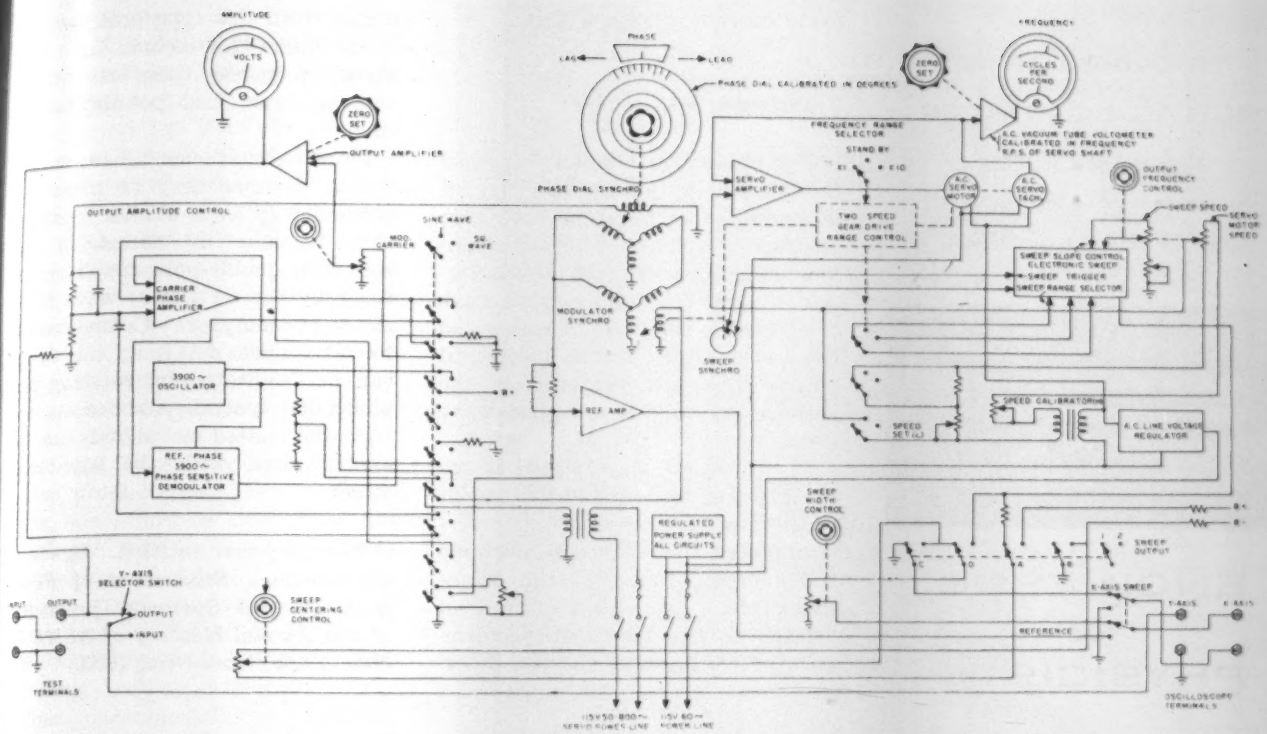


Fig. 1—Block diagram of equipment to measure frequency response and transient response of feedback control systems. This instrument is a combined signal generator and calibrated signal phase shifter and cathode ray indicator

entation on the scope is adjusted to a conventional magnitude on the cross-hatched scale of the oscilloscope. At this frequency negligible difference between input and output will be exhibited by the servo under test, both in amplitude or phase. Therefore the output signal from the servo under test will be essentially in phase with the sweep signal.

As the sinusoidal forcing frequency is increased, however, the servo under test will show a lag which is manifest by its output being late with respect to the sweep signal. By rotating the rotor shaft of stationary synchro the pattern may be adjusted until it is again in step with sweep signal. This is accomplished by causing the input signal to the servo being tested to lead the sweep signal an amount sufficient to compensate for the lag taking place in the servo. The amount of lag may be read directly on the dial of the stationary synchro.

Readings of phase are similarly taken for other values of frequency in convenient steps over the entire frequency range of interest. Resulting frequency range of interest is usually the band of frequencies between a frequency where very little phase shift occurs to one which is several octaves above the natural or resonant frequency. At the same time that phase-angle measurements are being made, amplitude measurements are made. This can be done conveniently by observing the amplitude of the envelope as presented on the scope. Resulting frequency-response data may be then plotted as amplitude and phase versus frequency.

In measuring the frequency response of a dc system, the modulating synchro is excited from a 3900-cycle oscillator. The resulting sinusoidally modulated 3900-cycle signal is demodulated to remove the 3900-cycle carrier. The result is a low-frequency sine wave, variable in frequency, and whose phase may be varied with respect to either a saw-tooth sweep signal or a sinusoidally modulated 3900-

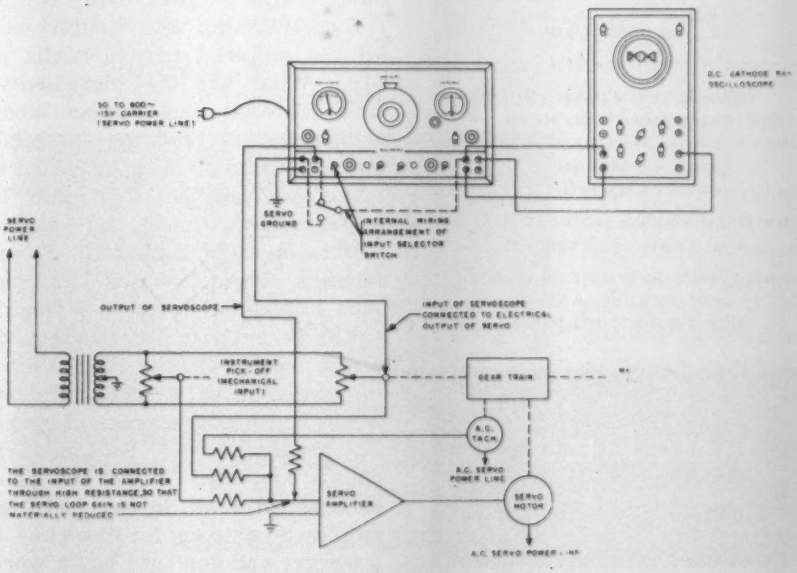

50 TO 800 ~ 115V CARRIER (SERVO POWER LINE)
D.C. CATHODE RAY OSCILLOSCOPE
SERVO GROUND
INTERNAL WIRING ARRANGEMENT OF INPUT SELECTOR SWITCH
SERVO POWER LINE
OUTPUT OF SERVOSCOPE
INPUT OF SERVOSCOPE CONNECTED TO ELECTRICAL OUTPUT OF SERVO
INSTRUMENT PICK-OFF (MECHANICAL INPUT)
GEAR TRAIN
A.C. TACH
A.C. SERVO POWER LINE
THE SERVOSCOPE IS CONNECTED TO THE INPUT OF THE AMPLIFIER THROUGH HIGH RESISTANCE SO THAT THE SERVO LOOP GAIN IS NOT MATERIALLY REDUCED
SERVO AMPLIFIER
SERVO MOTOR
A.C. SERVO POWER

Fig. 2—Test arrangement of equipment to measure frequency response data. Amplitude of the input signal under test should be set at a value that will not cause saturation in the servoamplifier

TRANSISTOR &
DIGITAL COMPUTER
TECHNIQUES

applied to the design, development and application of

AUTOMATIC RADAR DATA PROCESSING, TRANSMISSION AND CORRELATION IN LARGE GROUND NETWORKS

ENGINEERS
&
PHYSICISTS

Digital computers similar to the successful Hughes airborne fire control computers are being applied by the Ground Systems Department to the information processing and computing functions of large ground radar weapons control systems.

The application of digital and transistor techniques to the problems of large ground radar networks has created new positions at all levels in the Ground Systems Department. Engineers and physicists with experience in the fields listed, or with exceptional ability, are invited to consider joining us.

FIELDS INCLUDE

TRANSISTOR CIRCUITS
DIGITAL COMPUTING NETS
MAGNETIC DRUM AND CORE MEMORY
LOGICAL DESIGN
PROGRAMMING

VERY HIGH POWER MODULATORS AND TRANSMITTERS

INPUT AND OUTPUT DEVICES
SPECIAL DISPLAYS
MICROWAVE CIRCUITS

Scientific and Engineering Staff

HUGHES

RESEARCH AND DEVELOPMENT LABORATORIES

Culver City, Los Angeles County, California

cycle carrier reference signal.

Transient-Response Test

For obtaining transient-response information a square-wave signal is generated by the servoanalyzer; this wave is supplied in synchronism with the saw-tooth sweep signal voltage. When the square wave is applied to the vertical plates and the sweep signal to the horizontal plates, the presentation on the cathode-ray tube is in square-wave form.

If the square-wave signal is applied to a dc system and the output of the system is applied to the vertical plates, the result depends upon the damping factor of the device under test. Quantities of interest related to the transient performance of the system may be determined from this type presentation. These quantities include the overshoot, response time, rise time, settling time, and possibly dead-time.

Transient-response measurements for ac systems may be measured conveniently in a similar manner. This is done by energizing the coil of a double-pole double-throw relay by the dc square wave from the servoanalyzer. Compensation for the time delay in the relay can be facilitated by rotating the phase dial synchro, and the square-wave-modulated ac signal can be synchronized with the saw-tooth sweep.

From a paper entitled, "Dynamic Performance Evaluation of Feedback Control Systems" presented at the Annual Meeting of ASME in New York, Nov.-Dec., 1953

WEALTH OF A NATION

by F. C. CRAWFORD
Thompson Products Inc.
Cleveland, Ohio

PRODUCTIVITY is the extraordinary secret of our wealth in America. I have been around the world. I have talked to businessmen and government people in many countries, and this is the approach that I try to make with them.

You say you need more wealth. You need help. What is wealth? I think wealth is any useful thing. Modern life requires many things—food, clothing and shelter, and all the material paraphernalia of life. What are the ingredients? Raw material plus human labor. God gave us the raw materials but human labor must be added to make them usable. Coal must be mined, food must be raised, clothes must be fashioned. So my formula becomes raw material plus human labor creates wealth.

But in modern America nobody works hard. That is the astounding thing about America. Nobody works hard in the sense of grinding physical labor. So I want to change my word "labor" to "time" because after all, in our factories, don't we contract for the time of a worker and don't we pay a worker by time? So let me change my formula to raw material plus time creates wealth.

But of these two, time is by far the more important. As stated before, God gave us raw materials. Their cost is really little more than the value of the labor or the time spent in securing them. A ton of coal is worth only a few cents in the ground, but in your coal bin it may represent as much as 20 dollars of wealth. The difference is a measure of the time spent in mining it, cleaning and sifting it, and transporting it.

Time is more important than raw material in another sense. Raw material secured one day but not used is still available for use the next day. Time, on the other hand, is fleeting—purchased one day but not used, it is gone forever. Time is the most important, most costly, and most wasted thing on earth. Let me emphasize this by further simplifying my formula. Time turned into useful things creates wealth.

American Concept

Few disagree with my story up to this point. In my travels all over the world, managers have

nodded approval and understanding. But now, as we proceed in our analysis, we come to the parting of the ways.

To Americans it is obvious that if time is turned into things slowly, less wealth results; if time is turned into things rapidly, more wealth is created. We call the rate at which we turn time into things productivity—a much misunderstood word. And highest productivity is the goal of American management.

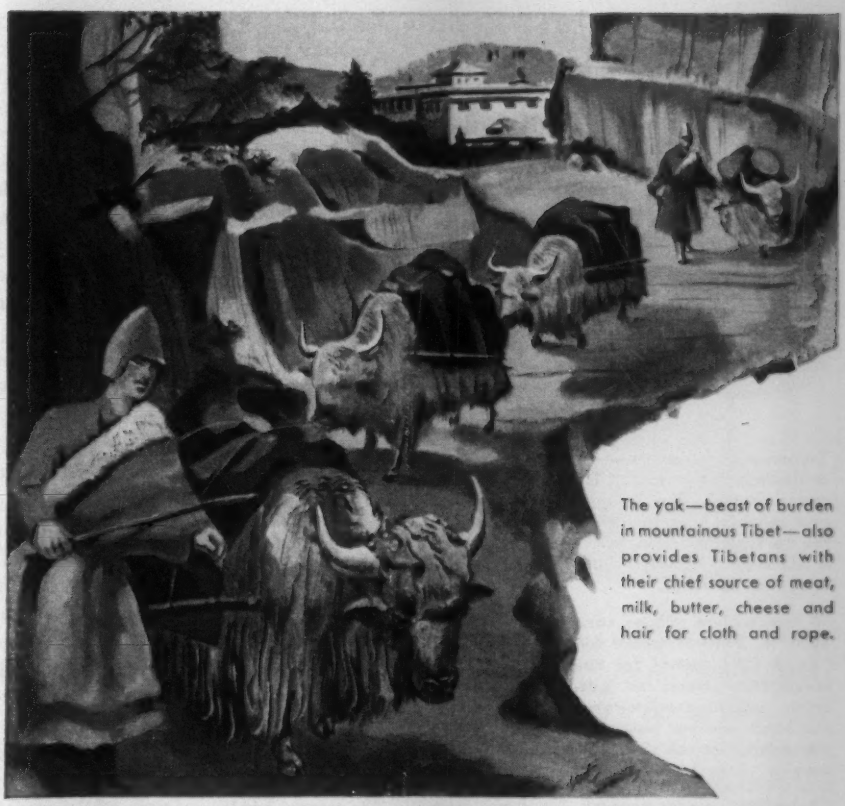
Call it cost reduction, efficiency, mass production, or what you please, it is merely an effort to raise productivity. We businessmen buy hours of time from our workers, but we sell the things our workers produce. Double the output from the same hours of time, and wealth is doubled. All the machines, tools, methods, engineering, selling, financing, and other paraphernalia of business exist merely to help the worker turn his hour of time into more useful things faster.

Productivity is America's secret of wealth. It is the source of abundance so envied by poorer nations. Higher wages; better products and values; improved health facilities; greater educational opportunities; more leisure—all are the results—all go to make up our higher standard of living.

And now for my law of productivity: Anything which turns time into things faster, increases wealth. Anything which hinders the process of turning time into things reduces wealth. All this seems so simple, yet only we in this country seem to grasp its meaning. It is a state of mind, typically American. This is the great difference between America and most other lands.

More Employment, Not Less

Many people abroad are sure that modern machinery will increase unemployment. I told them of my experience. Thiry-eight years ago when I first went to work, my company employed 200 workers. The bankers said costs had to be cut in order to avoid bankruptcy. This meant reduced employment and more labor-saving machinery. For 38 years we have



The yak—beast of burden in mountainous Tibet—also provides Tibetans with their chief source of meat, milk, butter, cheese and hair for cloth and rope.

MULTI-PURPOSE CONVEYORS

Modern industrial conveyors are frequently designed to accomplish more than one useful production operation.

That's why some of Allied's most interesting and unusual installations have been those that best illustrate *Allied* ability and versatility for creating multi-purpose material handling equipment.

Allied have been Automation specialists for years—their installations include various types of conveyors, multiple transferring equipment, and highly engineered, fully automatic material handling systems.

If you are faced with a peculiar kind of material handling problem, you can confidently expect Allied to come up with a dependable and efficient solution.

PIONEERS IN AUTOMATION . . . *the design and fabrication of fully automatic material handling systems*

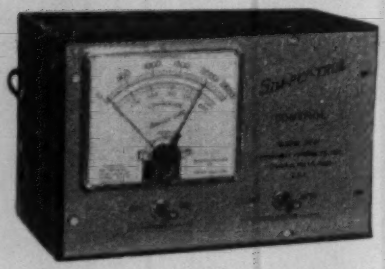
One example of highly specialized Multi-purpose Equipment is this combination Tire Inflater, mounter and conveyor, designed and built by Allied for an automobile manufacturer.

For further information request Allied Catalog 953

ALLIED AUTOMATION DIVISION
ALLIED STEEL and CONVEYORS, INC.
17371 Healy Avenue, Detroit 12, Michigan

(Advertisement)

SIMPLYTROL AUTOMATIC PYROMETER



Cat. No. 4531 0/2500° F.
Price $132.00

Thermocouple type Automatic Pyrometer for controlling temperature in furnaces, ovens, and processes. The Simplytrol is economical and reliable with few moving parts. There are no vacuum tubes. The regular load relay is S.P.D.T. 5 Amps. Optional heavy duty relays to 40 Amps.

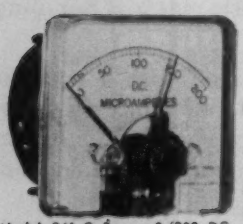
10 temperature ranges cover from —75° to 3000° F. Several special ranges to —400° F. "On & Off" control for holding the desired temperature works on gas, oil or electric heat. Indicating meter-relay is medium high resistance and has bimetal cold junction compensation. For use with all standard thermocouples. Accuracy 2%.

"Auto-Limit" switch changes Simplytrol from automatic controller to limit pyrometer for safety shut down or warning. Cabinet: 6½x6½x9½ inches. Also flush panel mount models. Send for new Bulletin G-7 for more data. Assembly Products, Inc., Chesterland 27, Ohio.

Booth 311, I.R.E. Show, March 21-24

METER-RELAYS

For Sensitive and Accurate Control



Model 261-C Range 0/200 DC Microamperes Price $33.00

RANGES:

0/20 Ua. to 0/50 A.
0/5 Mv. to 0/500 V.

The trip point is adjustable to any point on the scale arc. These meter-relays are sensitive to changes of as little as 1%. One contact is carried on moving pointer. The other is on a semi-fixed pointer. When two pointers meet contacts close and lock. Holding coil is wound directly over moving coil. Reset can be manual or automatic. Spring action in contacts kicks them apart forcefully. Three sizes of clear plastic case models, 2½, 3¾ and 4½ inches (all rectangular). Two ruggedized and sealed models, 2½ and 3½ inches (round metal cases). Contact arrangements: High Limit Single, Low Limit Single or Double (both high and low). Contact rating is 5 to 25 milliamperes D.C.

Suggested circuits for meter-relays and complete specifications including prices are covered in new 16-page Bulletin G-6, which you can get by writing Assembly Products, Inc., Chesterland 27, Ohio.

been buying all the labor-saving machinery we could get our hands on in order to get rid of those 200 workers, yet today our employment is 25,000. That is the paradox of job-making so little understood around the world—make jobs by doing it by hand and employment falls. Add productivity-increasing machinery, get rid of people and your employment climbs.

Most of us live so close to American industry that we hardly see what is happening. Industry is just emerging from its infancy. It is just on the threshold of enormous possibilities. Science has branched out in a thousand ways with new products, new processes, new machinery, new opportunities — a thousand times what they were 20 years ago. There's an extraordinary increase possible in the productivity of this country. The industrial dream is that finally in our plants machinery will do all the work and men at very high wages will merely tend the machines.

The Road Ahead

If we keep our freedom, if we keep our right to produce, free from the controls and hindrances that plague Europe today, we can double the productivity of America in a decade. And what a profound effect that will have upon our American economy! It will halve the cost of things and when you cut the cost in half, you cut the price of things and you double the purchasing power. That's possible in 10 years in this country, if we are allowed to do it.

Moreover, this great increase in material wealth that is possible just ahead of us is our margin of power in a world of trouble. Our influence around the world depends on it—our strength to maintain peace, our strength to win wars, to carry and pay our debt, to face inflation and to raise the standard of living, all at the same time. Management's job is to fight always for the right to increase productivity.

Henry Ford expressed the philosophy of productivity when he told the farmers, "There is no virtue in the sweat of the brow. It is the size of the crop that matters."

From a talk entitled, "America's Open Secret" given at a meeting of the Society of Industrial Realtors in Cleveland, Nov., 1954.

AUTOMATION IS CATCHING

F. O. HESS
Selas Corp. of America
Philadelphia, Pa.

AUTOMATION is a new word, but it has already assumed many meanings and interpretations. Therefore, let us first analyze and stipulate what we understand or mean before we try to establish any relationship and effect upon the gas industry.

To the conveyor man automation means materials handling by machinery or mechanical means in the broad sense, which includes pneumatics and hydraulics. To the instrument man it means gages, controls, signals, relays, electronic devices, computers and corrections. To the machine tool builder it means the performance of several operations simultaneously or in sequence in one or more machines.

If that is the meaning of automation it is nothing particularly new because it has been going on for years, almost since the beginning of the machine age. Present day automation would be just a matter of degree when compared to previous concepts or practice. Even I can remember about 25 years ago being involved in the design of a single automatic machine for producing hinges for doors. This machine was fed with wire from a spool and also with strip steel. From the wire a hinge pin was formed properly headed; from the strip two hinge plates were formed; holes for the screws were drilled and properly countersunk; the hinge pin was driven into the assembly; and the assembly neatly folded flat. All that was performed in one machine at the rate of one hinge every few

seconds. There it was, a complete process from raw material to finished product with a counter to record the daily or hourly production.

Automation in its proper sense and interpretation includes, or starts with, the full economic considerations of our advanced technology; our local requirements and resulting appropriate re-evaluation or rethinking of our entire production operations, the product, its purpose, its design, the process of production in terms of functions rather than operational steps now performed.

Case History

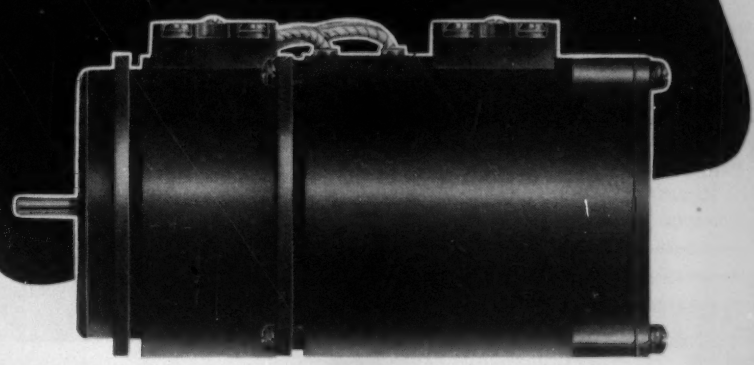
To illustrate such a meaning and also to lead us into our gas business, I would like to cite one example—blowing of electric bulbs. The immense market was obvious, so was the need and demand. If we were to attempt to supply today's hourly demand for electric bulbs, by using 1927 production methods, we would require 75,000 employees, and even with 1934 techniques, we would still require 4,000 employees. Such a labor army was obviously an impossible answer to the needs and demands of the electrical market. Therefore the economics of the entire process and the product required a reanalysis with the result that today electric bulbs are blown in an automatic process at the rate of 90,000 per hour with 230 employees.

Since 1934 this progress has been accompanied by an 80 per cent reduction in lamp cost. The product was reshaped, quality and uniformity were improved. But this production is not obtainable without control of the raw material and control of the conversion of this raw material into glass by melting. Manual control for either batch preparation or for melting would not permit such automatic blowing rates or the automatic blowing process because of wide variations and high losses or, in reverse, low yields. Only by a thorough refinement and control of the entire process is such improvement in production and quality possible.

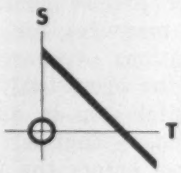
This process, as most other production processes, requires heat and unless this heat in its effect on the

Tachometer Feedback

with Instrument Servo Motors



and now, a DIEHL Instrument Servo Motor and Integrally-Mounted Alternating Current Tachometer-Generator assures stability in a Servo loop. Designed for simple and easy mounting and can readily be adjusted after installation so that the in-phase residual voltage is essentially zero. A high impedance control-phase winding is available for plate to plate operation. 57½/57½ volt control-phase windings can be provided for magnetic amplifier applications. Diehl Motor-Tachometer combinations are obtainable with Gear Reducers in 5 different ratios. Attractively priced for commercial applications.



Visit us at
BOOTH 3
Kingsbridge Palace
Radio Engineering Show
March 21-24

MOTOR RATINGS	TACHOMETER SPECIFICATIONS	
1, 5 and 10 watts output	Input (volts)	115
GEAR REDUCTION RATIOS	Frequency (cycles)	60
191.1 to 1 76.6 to 1 32.4 to 1 13.8 to 1 5.8 to 1	Output (volts per 1000 RPM)	5.5
	Linearity	1%

Our engineering staff will gladly help you select the equipment best suited to your requirements. A request on your letterhead will bring you a copy of Technical Manual No. A-355 describing Diehl Servo Motors and related equipment.

Other Available Components:
D.C. SERVO SETS • RESOLVERS
MINIATURE PERMANENT MAGNET D.C. MOTORS

Diehl

DIEHL MANUFACTURING COMPANY
Electrical Division of THE SINGER MANUFACTURING CO.
Finderne Plant, SOMERVILLE, N. J.

AUTOMATION
CONSULTING SERVICE

OPERATIONS RESEARCH CORP.
a division of
THE DR. ROY HERRMANN ORGANIZATION
Tel. MUrray Hill 2-3077
501 Fifth Avenue • New York 17, N. Y.

LOWE, WHITE & COMPANY
ENGINEERS • AUTOMATION SPECIALISTS
Willoughby 2-6734
38809 Mentor Avenue • Willoughby, Ohio

WHEELER ASSOCIATES, INC.
• *Automation* • *Plant Layout*
• *Operations Research* • *Engineering*
• *Materials Handling* • *Design*
"Designed to Reduce Your Cost"
15017 Detroit Ave. Cleveland 7, Ohio
Telephone—LAkewood 1-0300

GEORGE H. KENDALL
Consulting Mechanical Engineers
Methods Studies: Process or Product Redesign Existing Products for Greater Profit, Trouble Shooting Production, Design, Cost Problems, Specialist Automatic Machinery, Process, Controls, New Developments, Patent Studies, Investigations, New Products & Process Engineering Studies
P. O. Box 3 *(Est. 1923)* Tel. Darien 5-1504
Noroton Heights 3 Offices Darien, Connecticut

THULIN, WOODS & ISENSEE
Consulting Engineers
Special Machinery • Product Design
Plant Evaluation
105 S. La Salle St. • Chicago 3, Illinois

EXECUTIVE SERVICES
Applied Mathematical Management
TRAINING
• Mathematical Programming
• Inventory Management
• Production Control
COUNSELING
• Operations Research
• Hi-Speed Computers
• Systems
SUperior 1-7110
1040 National City Bank Bldg. Cleveland 14, O.

GEORGE H. KENDALL
Consulting Mechanical Engineers
SPECIALISTS IN AUTOMATION PROCESSES
CREATORS OF THE FAMOUS MULTRA MACHINES FOR MACHINE ASSEMBLY
P. O. Box 3 *(Est. 1923)* Tel. Darien 5-1504
Noroton Heights 3 Offices Darien, Connecticut

ADRIAN WILSON
AND ASSOCIATES
Architects • Engineers
Complete Plants—Master Planning
Industrial Communities
Air Fields—P.O.L. Installations
Hospitals—Office Buildings
Los Angeles • Washington, D. C.
Japan • France • Greece • Turkey
816 West Fifth Street, Los Angeles, Calif.

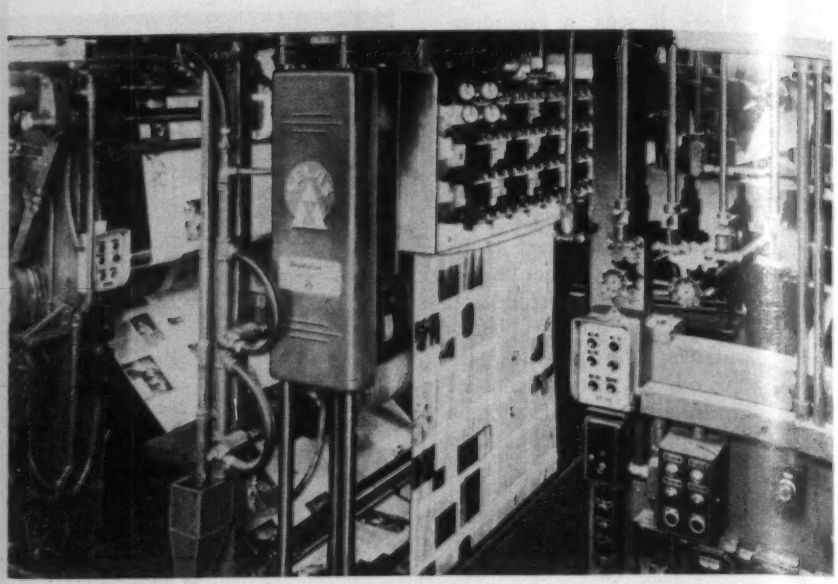


Fig. 1—Automatic high speed printing at Conde-Nast where several national magazines are printed utilizing Selas Gradiation heating

process is under precise control, with corrective measures for errors and variations (occurring from or during the operation) we are lacking a vital step in automatic production. That is, of course, where gas enters the picture. Gas is the foremost heat generating medium in our industries, and we all know that it is controllable. Therefore the more automation the more gas fuel.

Automation Thinking

My ulterior motive behind the preceding remarks and examples was of course, to illustrate to you that the situation of gas in automation is not as simple as that. If automation implies the rethinking of our production processes, including heat operations or treatments, and the application of control as to time, measurement, dimensions, temperature, etc. and corrections for errors, our heat generation medium must be subjected and responsive to such controls.

We have to analyze what to heat and how, and to what degree and within what time, and for how long. Then we have to take our method of heat generation—the gas combustion process—and control it as to intensity, area, heat generation and distribution and heat transfer rate, all with the end product in mind and the result upon product which, after all, is the really decisive control factor. And often we cannot even measure the temperature of the material we are heat processing because it is moving, like glass in our lamp ma-

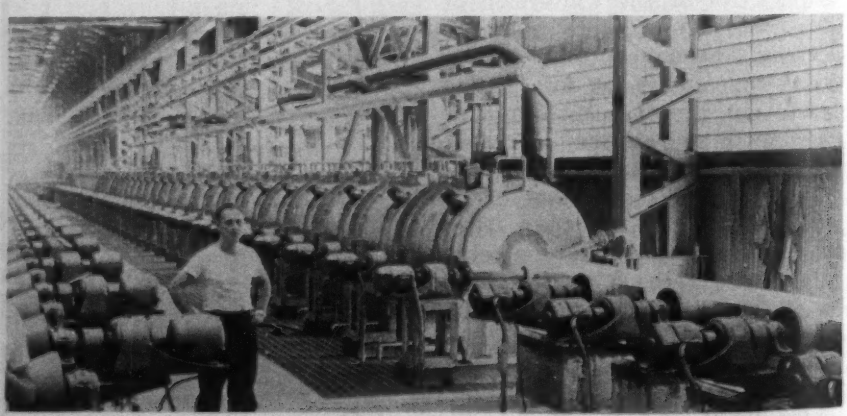


Fig. 2—Continuous short cycle normalizing of pipe at speeds of over 100 fpm

chine; a fact which requires process engineering around our instrument or measurement short-comings.

Furthermore, all this has to be done in all kinds of industry; all kinds of heating and heat treating operations; all kinds of heat processing plants, such as refineries. It has been about 15 years since we first applied and publicly advocated high-speed heating methods as a means to co-ordinate heating operations with modern manufacturing trends. Since then this concept of gradient heating has been vastly expanded and accepted, and production line heat treatment has facilitated incorporating heat processing into automatic operations. For example, I refer to ink drying on printing presses, *Fig.* 1, which progressed from new inks to new presses to news magazines printed, folded and shipped the same day—an example of process rethinking and development. I refer to continuous welding of line pipe and continuous short cycle normalizing, *Fig.* 2, at speeds in excess of 100 feet per minute for 8 inch pipe—in-line production with a superior end product at a fraction of previous time consumption.

We can include continuous annealing and galvanizing of steel strip, continuous fusing of electrolytic tin-plate, continuous annealing of steel for tin-plate use and short cycle annealing for cold extrusion operations. In three of these processes batch operations of the steel industry are being converted to continuous operation in strip form, performed so fast that direct firing with gas does not produce oxidation.

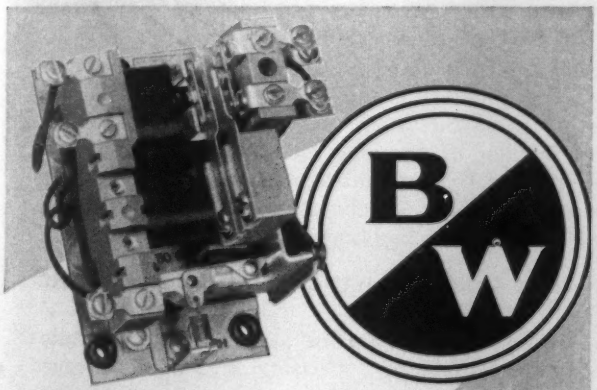
Upgraded Labor

Any discussion of automation should include another important effect—the tremendous increase in dependence on the human being and the local changes which arise therefrom. Take as an example high speed rolling mills.

Only a few years ago ten small mills were operated for the rolling of tin plate in one steel plant. These ten mills required ten operating crews. Today, one mill furnishes the entire output of the previous ten mills with but one crew. The machinery, however, is many times more complex. Not only can it be stopped by the failure of one small relay, but one man can stop the entire plant production. The new crew is of a higher grade with longer training, and an entirely new and different sense of responsibility has to exist or be created. If this cannot be done, and the appropriate relationship cannot be established between operating forces of automation processes, an important limitation exists to the technical potentials of automation.

Summarizing, automation is like a state of mind. Therefore, we can say that automation demands advanced, progressive engineering, fuel engineering, process engineering and human engineering, inside and outside of the gas industry.

From a talk entitled, "Automation and the Gas Industry" given at a meeting of the American Gas Association in Chicago, Nov., 1954



floatless
LIQUID LEVEL
and **INDUSTRIAL CONTROLS**

• Write for latest catalog covering the complete line of B/W Induction Relays, Relay Enclosures, Contactors and Starters, Multiple Pump Controls, Electrode Holders, Starter and Relay Combinations, Special Controls and Panels.

Controls will never trouble you, when you buy B/W

B/W CONTROLLER CORPORATION
2190 East Maple Road, Birmingham, Michigan

Automatic
PRESS LINES
WE
DESIGN AND BUILD
COMPLETELY AUTOMATIC
PRESS LINES
THE SPEED OF THE PRESS
CONTROLS THE
QUANTITY OF PRODUCTION

Hamilton *Inc.*
Automation
1490 EDISON AVE. ② HAMILTON, OHIO

AUTOMATION

PATENTS

Copies of patents are available at 25 cents each from the Commissioner of Patents, Washington 25, D. C.

Controls

AIR OPERATED CONTROLLER

Float operates a pivotally mounted drive lever which is connected to the driven lever through a fixed adjustable cam which compensates for differences of specific gravity of various liquids being measured. Driven lever operates inlet or exhaust valve of valving arrangement that controls flow of air either from compressor to controller or from controller to waste; thus regulating the air operated motor for a final control valve. Patent 2,698,025 by Arthur H. Jordan, assigned to Minneapolis-Honeywell Regulator Co.

AUTOMATIC AIR BLEED FOR HYDRAULIC FORCE MEASURING SYSTEMS

Loaded cylinder is connected to a means for supplying liquid under pressure and to a gage through a valve which is on the gage side of a restricted vent in the communicating passageway. Valve automatically opens when the pressure exceeds a certain value and closes when the pressure drops below a predetermined value. Patent 2,700,303 by Marshall W. Galliers, assigned to Curtiss-Wright Corp.

• • •

Handling

STRIP STACK DEVICE

Flat metal strips are fed off the delivery end of a conveyor onto a plurality of parallel tracks each of which has a carriage unit with a vertical post on its end remote from the conveyor. Shaft, transverse to the tracks, has one gear for each carriage which by engagement with a rack under the carriage can vary the distance between the posts and uprights on the end of the rails. Bottom of pile of strip resting on the rails is accessible to a lifting device for removal from the stacker. Patent 2,698,100 by Ernest Fried, assigned to Fried Steel Equipment Mfg. Corp.

METHOD OF AND APPARATUS FOR HANDLING SLIT COILS

Device receives a group of coaxial slit coils as a unit with their common axis extending horizontally. Another removes these coils one by one and lays them down so that a device can sequentially advance the thus laid down coils. Patent 2,700,332 by William P. Donald, assigned to Wean Equipment Corp.

STRIP FEEDING DEVICE

Intermittently operated mechanism for an imprinting machine comprises a strip feeding device with its actuating means which includes a program controller which tends to operate in synchronism with the imprinting machine. Detent releases member in regular series progression but has overriding control which can be operated to change the series progression. Patent 2,700,334 by John T. Davidson and John A. Schmidt, assigned to Standard Register Co.

• • •

Machines

METHOD AND APPARATUS FOR MAKING FIBERBOARD WITH PREPRESSED MARGINS

Comprises forming comminuted lignocellulose into a mat, pressing the longitudinal margins to a predetermined degree, removing lignocellulose from the surface of the mat between the compressed margins and consolidating the mat to a predetermined density. Patent 2,700,177 by Arthur L. Mottet, assigned to Long-Bell Lumber Co.

MACHINE FOR AUTOMATICALLY VARNISHING ELECTRICAL RESISTORS

Coating station receives article as it gravitates from rotating feeder. Coating substance is forced onto the article as it rests on the support. Another rotating element lifts the coated workpiece from the support prior to deposit of the next successive part thereon. Patent 2,700,368 by Victor A. Woodell and Paul R. Hannaway, assigned to Electra Mfg. Co.

• • •

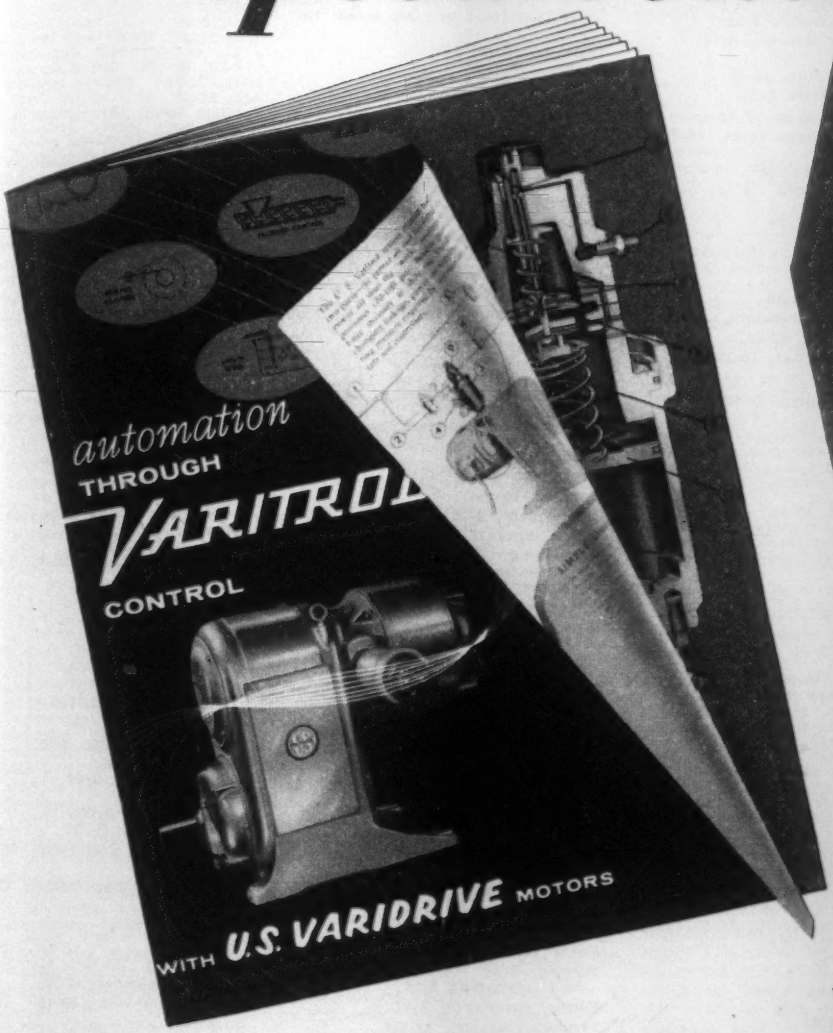
Machine Tools

AUTOMATIC METAL FORMING MACHINE

First threaded cutter threads one end of a workpiece, machine has transferring device to locate workpiece on a pilot and clamp it in position for the other end to be automatically threaded by rotatable second cutter. Patent 2,700,167 by Marinus Heymering and Cecil W. Hopkins, assigned to Landis Machine Co.

Free! THIS BRAND NEW BOOKLET ABOUT

automatic speed control



HOW TO APPLY THE ADVANTAGES OF VARIABLE SPEED TO AUTOMATION

Typical applications of Varitrol pneumatic control regulating the speed of Varidrives in response to a signal from such variables as temperature, humidity, pressure, speed, liquid level, weight and tension are dramatically pictured and explained in this full-color booklet. How the Varitrol pneumatic system functions is illustrated with full-color cross-section drawings and diaphanous views of the U. S. Varidrive with exclusive right angle speed-changing linkage. This educational booklet, edited by variable speed engineers, is your guide to a method of greater production of more goods and services at lower cost and astounding man-hour savings. Write today for your complimentary copy.

U. S. ELECTRICAL MOTORS INC.
Los Angeles 54, Calif. • Milford, Conn.

U. S. VARIDRIVE

WITH VARITROL® MOTORS

FOR VARIABLE SPEED AUTOMATION

REQUEST FOR VARITROL BULLETIN

U. S. ELECTRICAL MOTORS INC.
P. O. Box 2058, Los Angeles 54, Calif. or Milford, Conn.
☐ Send Varitrol Automation Booklet No. 1882
☐ Send U. S. Varidrive Booklet No. 1797

Name_____

Company_____

Address_____

City_____ Zone____ State_____

CUMULATIVE EDITORIAL INDEX

Including six issues. Number preceding the hyphen is month of issue; those following are page numbers in that issue.

A

Abbe, E. H.
Heavy Material Handling, 2-26
Accounting, 12-31
Air cooling systems, 1-30
Air gaging, 11-21
cartridges, 1-102
Air sampling, 1-111
Aircraft, auto pilot, 3-66
Amplifier,
diode, 1-45
magnetic, 11-112,116
Analog computer, 10-96
Analog to digital conversion, 10-41; 12-98
Analysis,
dielectric, 12-108
mathematical, 11-110
process stream, 11-46
Annealing, 3-26
Appliance manufacture, 3-56
Arbors, loading, 1-18
Armature manufacture, 10-21, 105
Assembly, 10-23, 53; 11-12; 2-33
Atwood, S. G.
Layout for Handling, 10-46
Automatic control, 10-108; 3-66
bibliography, 3-110
merchandising, 3-110
terminology, 10-51; 11-59; 12-63; 1-49; 2-61; 3-37
Automatic elevator, 10-104
Automatic machines, 1-16
Automatic systems, 11-47
Automation,
application of, 2-8
concepts, 10-100; 1-10
definition of, 10-18
history, 10-102
in the office, 10-50; 12-31; 1-39; 2-65
job shop, 10-46
philosophy, 2-117; 3-100
planning for, 10-18, 47; 3-41
product design, 11-18
steel industry, 11-107
survey, 3-41
Automobile manufacture, 2-8
Automotive parts manufactured, 10-20; 12-22; 2-62, 122
Auxiliary operation, 11-30
loading arbor, 1-18

B

Balancing, 10-38
Batch process, proportioning, 3-17
Behrend, R. H.
Assembling Low-Budget Jobs, 10-53
Behrens, W. J.
Continuous Heat Treating, 3-26
Berg, R. H.
Continuous Weighing of Solids, 11-39
Bibliography, automatic control, 3-100
Bin, weighing, 11-39
Binary number system, 10-42; 3-56
Bishop, L. J.
Latex to Foam Rubber, Automatically, 11-31
Blast furnace, charging control, 2-29
Block diagrams, 3-37
Bolz, R. W.
Design for Manufacture, 11-18
More Automatic Operation, 3-41
Answer for Tomorrow, edit, 3-25
Bottle sealing, 11-23
Bottling, 3-64
Bowling, 12-107
Box making, 2-123
Broaching, 11-14
Business machines, 12-31; 1-39; 2-69

C

Camera, 11-14
oscilloscope, 1-12
Candle dipping, automatic, 1-22
Capacitors, electronic, 10-109; 2-127
Cards, punched, 10-9; 12-106; 2-65
Cartridges, air gaging, 1-102
Casting, 10-19
Cement product mixing, 2-59
Circuits,
control, 11-116
etched, 10-11
printed, 2-14
servoamplifier, 11-64
television, 2-31
Cleaner, ultrasonic, 12-102
Cleaning, metal, 3-55
Closed-loop,
concept, 10-57
systems, 11-111
Coal,
handling, 2-26
mining, 2-46
plant lubrication, 1-52
Coffee bean sorting, 2-74
Coin,
weighing device, 10-38
Collet, pneumatic, 3-15
Color sorting, 1-10; 2-74
Common language tapes, 12-31; 1-39; 2-65
Complex servos, 3-65
Computers, 12-109; 1-12; 2-10
analog, 10-96
component, 1-45
control, 1-9
digital, 10-108; 11-9; 12-14; 1-16; 2-12
elements, 10-97
mechanical, 10-96
Condenser manufacture, 10-20
Console control, 12-42
Contacts, electrical, 10-13
Contents, 3-3
Continuous gaging, 12-57
Control,
air pollution, 1-10
aircraft, 2-114; 3-16
blast furnace charging, 2-29
centerless grinding, 12-61
circuits, 1-62
closed-loop, 10-96, 101
electric arc furnace, 12-96
electrical, 10-104; 11-116; 12-66, 106; 1-22, 110; 2-28, 122; 3-36, 40
electronics, 10-28, 34, 39, 44; 12-8, 53; 1-9; 2-12; 3-62
engine fuel, 2-122
frequency, 12-106
furnaces, 3-32
gage, 1-55
hydraulic, 10-104; 1-62; 3-36, 106
ingot soaking pits, 2-10
instrument, 12-106; 3-106
machine, 10-98; 2-10
motor, 2-126
nozzle, 2-114
open-loop, 10-96
panel, 12-42
parallel disk grinding, 12-62
photoelectric, 10-35; 11-36; 3-62
pneumatic, 10-34; 11-116; 12-53
press unloader, 12-21
process, 3-66
refinery, 12-53
tape, 10-28; 12-9; 3-62
temperature, 10-104; 2-114
terminology, 10-51; 11-59; 12-63; 1-49; 2-61; 3-37
weight, 1-13
Controllers,
action, 12-63; 1-49
adjustment, 1-49
process, 3-66
Converters,
analog to digital, 10-41; 12-98
card to tape, 12-37
tape to card, 12-37
Conveying, 10-47; 12-106; 3-64
Conveyors, 10-35, 105; 11-34; 2-14, 126; 3-106
belt, 2-26, 46, 122
chain, 3-26
chip, 3-33
coal, 2-26
feeding, 12-41
idler, 2-122
ore, 2-26
overhead rail, 3-18
overhead screw, 2-73
pneumatic, 3-18
pump, 3-16
rubber, 1-9
slat, 2-122; 3-26
weighing, 11-39
Cooling system, air, 1-30
Counter, 12-107
Crankshaft manufacture, 2-62; 3-58

D

Data processing, 10-9, 12, 41; 11-9, 22; 12-31, 98, 106, 109; 1-12, 15, 16, 17, 39; 2-65, 122; 3-18, 55 110
Design, 11-116
Digital computers, 10-108; 11-9; 12-14; 1-16; 2-12
Diode amplifier, 1-45
Distribution: See warehousing
Drive and control system, 1-31
Drive, electronic variable speed, 10-44
Drum, memory, 3-55

E

Economics, 10-27; 1-33
Egg, handling & sorting, 12-27
Electrets, 10-109
Electrical,
arc furnace control, 12-96
control, 10-104; 11-116; 12-66, 106; 1-22, 110, 122; 3-36, 40
power, 10-17
timer, 1-70
transmission, 10-103
weighing, 11-40
Electronics, 1-12
capacitors, 10-109
control, 10-34, 39, 44; 12-8, 53; 1-9; 2-12; 3-62
diodes, 1-45
modular design, 11-19
servo, 11-61
tube, 10-8
Electroplating machine, 11-12
Elevator, 10-104
Employment, 3-101
Engine, aircraft, 2-122
Engineering,
organization, 2-35
systems, 11-47; 2-35; 3-49
Equipment data processing, 12-32
Experimental method, 10-108

F

Feedback, 10-57, 98; 11-49; 12-66
control, testing, 3-98
servos, 3-65
Feeders, 10-52, 104; 11-116; 3-106
pneumatic, 3-15
Filing, punched tape, 2-72
Film control, processing, 3-16
Finishing,
metal, 3-56
steel, 11-108
Fixture, magnetic, 3-15
Flowmetering of solids, 11-39
Foam rubber, 11-31
Forging, 3-58
heat treating of, 3-26
Forms, paperwork, 2-67
Frequency control, 12-106
Frequency response, testing, 3-98
Furnaces, 3-58
heat treat, 3-26
open hearth, 11-108

G

Gaging, 1-111; 2-123
air, 11-21; 1-102
continuous, 12-57; 3-40
cyclic processing, 1-55
for process control, 2-42
gear, 1-16
pushrods, 2-42
radiation, 11-108; 2-123
weighing, 1-111
wire, 12-59
wrist pins, 2-42
Garrott, P. B.
Automation in Paperwork, 12-31; 1-39; 2-65
Gear shaving and gaging, 1-16
Gittens, E. D.
Management of Systems Engineering, 2-35; 3-49
Grinding, 12-61; 1-55; 2-62
Gunnery, 3-66
Gyro, 2-16; 3-66

H

Hadekel, R.
Hydraulic and Pneumatic Servos, 10-57; 11-49; 12-43; 1-61; 2-49; 3-65
Handling,
coal, 2-26
conveying, 10-35, 47, 105; 12-27, 41, 97, 106; 1-9, 28, 57; 2-26, 46, 73, 122; 3-26, 58, 106
data, 10-9; 12-31; 1-39; 2-65
egg, 12-27
feeding, 10-52, 104; 11-116; 1-50; 2-62; 3-58, 106
ore, 2-26
orienting, 10-35, 104; 11-20
pallet, 3-64
parts, 11-58
sand, 1-16
sorting, 10-38, 104; 12-28, 107; 1-110; 2-74
unloading, 12-19; 1-50
Hardening, 3-26
Hardness testing, 11-10; 2-44
Heat processing, 3-102
Heat treating, 3-26
History, automation, 10-102
Holtje, M. C.
Feedback System Regulates Voltage, 12-66
Home appliance manufacture, 3-56
Hopper, weighing, 11-39
Humidification systems, 2-20
Hunting, 10-100
Hydraulics,
control, 10-104; 1-37; 3-36, 106
equipment, 1-31
presses, 10-53; 3-14
servos, 10-57; 11-49; 12-43; 1-61; 2-8, 49; 3-65
systems, 1-22; 2-115
weighing, 11-40

I

Indexing, 10-53; 11-62, 116
Induction heating, 11-104
Information, searching, 3-18
Inspection, 10-28, 38
automatic, 12-57; 3-40
Instruments,
control, 12-106; 3-106
recording, 1-110; 2-122
Integrated data processing, 12-31; 1-39; 2-65
Interchangeable manufacture, 11-18

J

Jaws, press unloader, 12-23
Job Shop Automation, 10-46

L

Labor, 1-25; 3-105
Lemon sorting, 2-74
Lift truck, 11-58
Light, 10-17
Loading,
arbors, 1-18
pallets, 10-35; 3-64
Lubrication systems, 1-52

M

Machine control, 10-98
Machine tools,
boring and facing, 10-10; 1-38

broaching, 11-14
fixture, 10-12
grinding, 12-61; 1-55; 2-18, 62
hydraulic press, 10-53
milling, 10-26; 12-107; 3-62
power brushes, 10-12
screw slotter, 10-44
threading, 3-106
tracer, 3-66
transfer, 3-33
trimming, 3-16, 58
turret lathe, 1-50
Machines,
assembly, 10-23
automatic, 1-16
box making, 2-123
business, 12-31; 1-39; 2-65
candle dipping, 1-22
cigarette making, 2-20
coil winding, 2-123
condenser winding, 10-20
electroplating, 11-12
extrusion, 10-105
fiberboard, 3-106
milling, 10-26
molding, 10-105
paper coating, 1-34
spline rolling, 12-41
unloading, 12-19
vacuum metallizing, 1-70
welding, 10-26
Magnetic
amplifier, 11-112
data storage, 3-55
fixture, 3-15
Maintenance, plant, 1-105
Management, 3-49
office, 12-31; 1-39
Manual control, 10-108
Manufacture of,
armatures, 10-21, 105
automotive condensers, 10-20
automotive parts, 12-22; 2-62, 122; 3-26, 33, 58
bearing races, 3-29
boxes, 2-123
crankshafts, 2-62; 3-58
cylinder heads, 1-38
dipped candles, 1-22
electrical resistors, 3-106
electronic tubes,10-8
fiberboard, 3-106
household appliances, 3-56
lamps, 3-103
petroleum products, 12-53
pipe, 12-106
piston rings, 2-122
rubber parts, 11-31
screwdrivers, 12-107
screws, 10-44
sheave and bracket, 10-53
splined shafts, 12-41
stamped parts, 12-19
starter brush end plate, 10-52
television circuits, 2-31
television tubes, 1-70
tubing, 3-40
Marvin, P. R.
Engineering Automatic Systems, 11-47
Mass production, 11-18
Materials, dielectric, 11-116
Measuring,
automatic, 12-57
gaging 11-21; 1-111; 2-123
instrument, 11-10
pressure, 1-10
temperature, 10-104; 12-9; 1-11
weighing, 1-111; 2-59
Mechanical, weighing, 11-40
Memory,
device, 12-28, 42; 2-122; 3-55
disk, 11-45
Merchandising, 3-110
Milling machine, 10-26; 3-62
Mining, coal, 2-46
Mixing, cement product, 2-59
Mobile color sorting, 1-12
Modular design of electronics, 11-19
Molding,
machine, 10-22, 105
rubber, 11-31

N

Networks,
hydraulic, 3-71
mechanical, 3-70
pneumatic, 3-71
Numbering code system, binary, 10-42

O

Office Automation, 10-50; 12-31; 1-39; 2-65
Oil refining, 12-53
Operations research, 2-118
Ore, handling, 2-26
Organization, engineering, 2-35, 3-49
Orienting, 10-35, 104; 11-20
Oscilloscope camera, 1-12

P

Packaging, 10-26, 32, 35; 1-111
bottle sealing, 11-23
egg, 12-27
imprinting, 3-20
Paint spraying, 11-44; 12-9, 107
Pallet loading, 10-35; 3-64
unloading, 3-64
Panel, graphic, 12-54
Papermaking, 12-8
Paperwork,
mechanized, 12-31; 1-39; 2-65
forms, 2-67
Peeps, D. J.
Pneumatic Control for Paint Spraying, 11-44
Photoelectric,
control, 10-35; 11-36; 3-62
sorting, 2-74
Photography, 11-12
Phototheodolite, 1-17
Pickling, 3-56
Pilot, automatic aircraft, 3-66
Piston ring, manufacture, 2-122
Planning, 10-18, 47
Plant layout, 10-46
Plating, tin, 11-109
Pneumatic,
controls, 10-34; 11-44, 116; 12-53
conveying, 3-18
feed, 3-15
servos, 10-57; 11-49; 12-43; 1-61; 2-49; 3-65
timers, 11-28
weighing, 11-40
Porcelain enameling, 3-56
Positioning, 11-61
Potentiometers, 10-109
Power, electrical, 10-17
Preamplifiers, 3-66
Presses,
conveyor type, 10-9
forging, 3-58
handling to, 10-49, 52; 3-14
hydraulic, 10-53; 3-14
trimming, 3-58
unloading, 12-19
Pressure measurement, 1-10
Printed circuits, 1-10; 2-14, 31
Printing, 10-26; 11-22; 12-9; 2-123
cloth, 11-28
Process control, 12-53; 3-66
Processing, continuous, 1-34
Product design, 11-18; 2-31
Production engineering, 2-118
Programs, 11-47
Project,
tinkertoy, 11-19
teams, 3-49
Proportioning,
batch process, 2-59; 3-17
ultrasonic, 10-10
Pumps,
controlled servos,1-67; 2-49
variable delivery, 1-61; 3-16
Punch press, 11-61
Punched cards, 10-9; 12-37, 106; 1-39; 2-65
Punched tape, 10-28; 12-31; 1-39; 2-65; 3-62
filing, 2-72
Pushrods, gaging, 1-111

R

Radiation, gaging, 2-123
Rainey, W.
Electronic Servo Positioning, 11-61
Recording,
camera, 11-14
data, 10-28; 12-12
instrument, 1-110; 2-122
tape, 11-12
weight, 11-12
Rectifiers, 2-14
Refining, 12-53
Regulating systems, 11-110
voltage, 12-66
Robots, 11-17
Rolling, steel, 11-108

S

Sampling, air, 1-111
Sanford, A. C.
Automatic Gaging, 12-57; 1-55; 2-42
Schroeder, C. J.
Automatic Machines Make Hand-Dipped Candles, 1-22
Screws,
conveyors, 2-73
slotting of, 10-44
Sealing bottles, 11-23
Searching, information, 3-18
Sehn, F. J.
New Vistas in Stamping, 12-19
Selling, 3-110
Semiconductors, 1-45
Servo,
positioning, 11-61
pump controlled, 1-67
systems, 1-61
Servoamplifier, 11-64
Servoanalyzer, 3-17
Servomechanisms, 11-116; 12-43
electrical, 10-104
hydraulic, 10-57; 11-49; 12-43; 1-61; 2-8, 49; 3-65
pneumatic, 10-57; 11-49; 12-43; 1-61; 2-49; 3-65
testing, 3-98
Servomotor, 12-66
Servosystems, hydraulic, 2-115
Shaft, armature manufacture, 10-22
Slide valve, 2-49
Slotter, 10-44
Soaking pits, ingot, 2-10
Solids,
continuous weighing, 11-39
flow metering, 11-39
Sorting, 10-38, 104; 12-107; 1-110; 2-42
coffee beans, 2-74
color, 1-10; 2-74
egg, 12-27
lemon, 2-74
photoelectric, 2-74
Spectrograph, x-ray, 2-18
Spectrometer, mass, 11-46; 12-11
Speed regulation, 11-112
Spraying 11-44; 12-107
Stampings, 11-8; 12-19
Standards, 10-51; 11-59; 12-63; 1-49; 2-61; 3-37
Statistics, 3-41
Steering control, 10-104
Stern, E. K.
Electromechanical Coder, 10-41
Survey, 3-41
Symbols, 3-37
Systems, 11-14
engineering, 11-47; 2-35; 3-49
humidification, 2-20
weight control, 1-13

T

Tapes,
common language, 12-31; 1-39; 2-65
control, 10-28; 12-9; 3-62
data processing, 12-31; 1-39
punched, 10-28; 12-31; 2-65
recording, 11-12; 2-10
Telemetering, 11-10; 12-106
Television, 11-108; 1-70; 2-31
Temperature,
measurement, 10-104; 12-9; 1-10
regulator, 1-14
Terminology,
block diagrams, symbols, control combinations, 3-37
characteristics of automatic control, 11-59
controller action, 12-63; 1-49
controller elements and characteristics, 2-61
processes, 10-51
Testing,
air sampling, 1-111
hardness, 11-10
nondestructive, 10-28; 3-40
ultrasonic, 10-28
Textile machines, 11-28
Thomas, A. G.
Electronic Tape Control System, 3-62
Thread cutting machine,3-106
Tice, C.
Pushbutton Manufacturing, 10-18
Timers, 11-28; 1-70
Tinkertoy project, 11-19
Tooling, 1-38
Tracer, machine tool, 3-66
Transfer machines, 2-62; 3-33
Transient response, testing, 3-98
Transistors, 10-109; 11-9; 12-109; 1-12, 46
Transmission,—
data, 10-9
electrical, 10-103
Trimming, 3-16, 58
Trucks, lift, 11-58
Tubing, manufacture, 3-40
Tying, 10-32

U

Ultrasonic,
industrial cleaning, 12-102
properties of liquid, 11-116
proportioning, 10-10
testing, 10-28
Unloading,
pallets, 3-64
press, 12-19

V

Valves, slide, 2-49
Variable delivery pumps, 1-61; 3-16
Vehicles, control, 10-104
Ventilation, 11-116
Voltage regulator, 12-66

W

Warehousing, 10-35
Washing, 3-56
Weighing, 11-12
automatic, 11-32, 37
continuous, 10-38; 11-39
Weight measurement, 10-102; 1-13, 111
Welding,
machine, 10-26
trimming, 3-16
tubing, 3-40
Winding machine, 10-20
Wire-tieing, 10-32

X

X-ray, spectrograph, 2-18